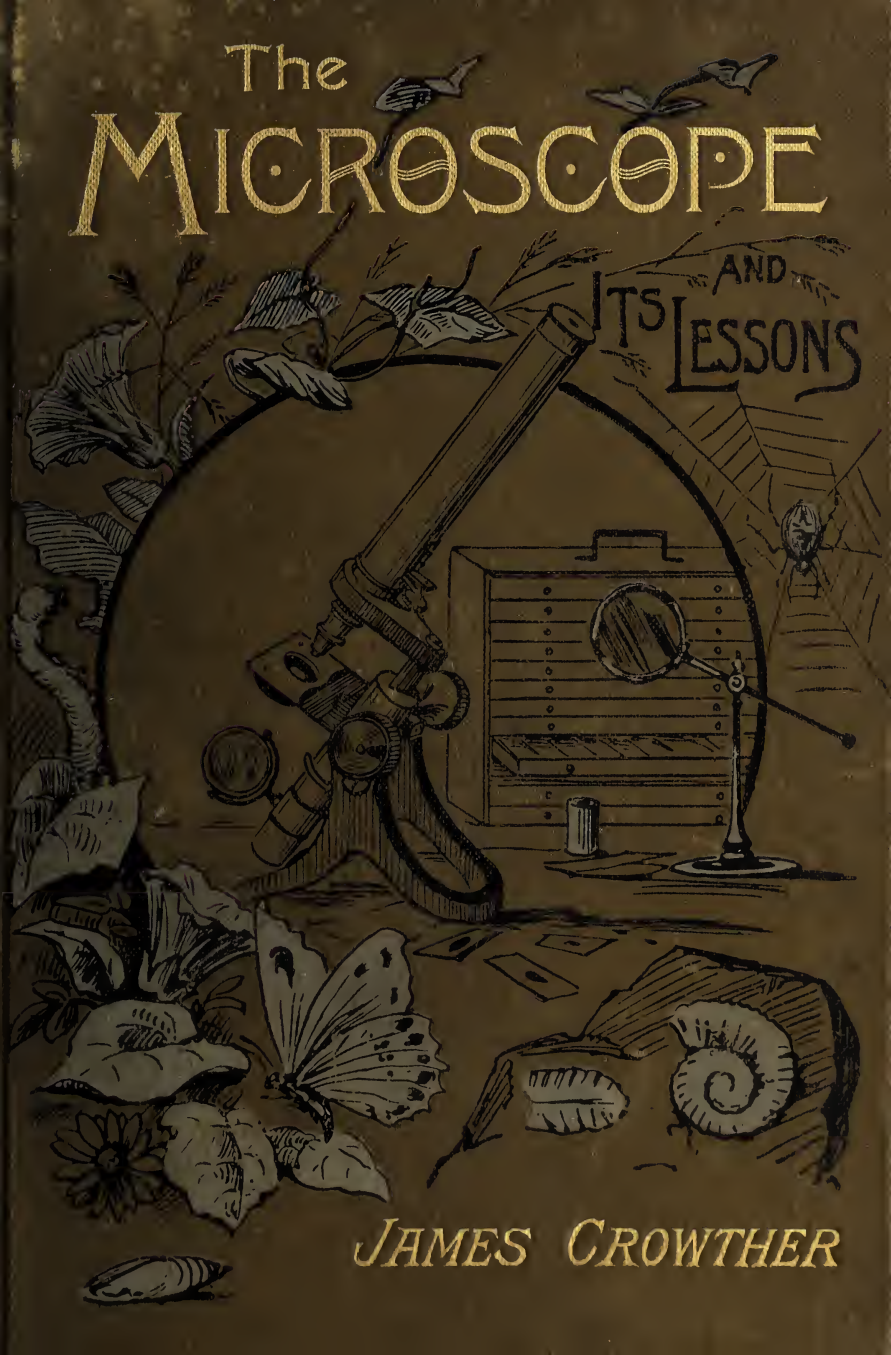
The MICROSCOPE AND ITS LESSONS



JAMES CROWTHER

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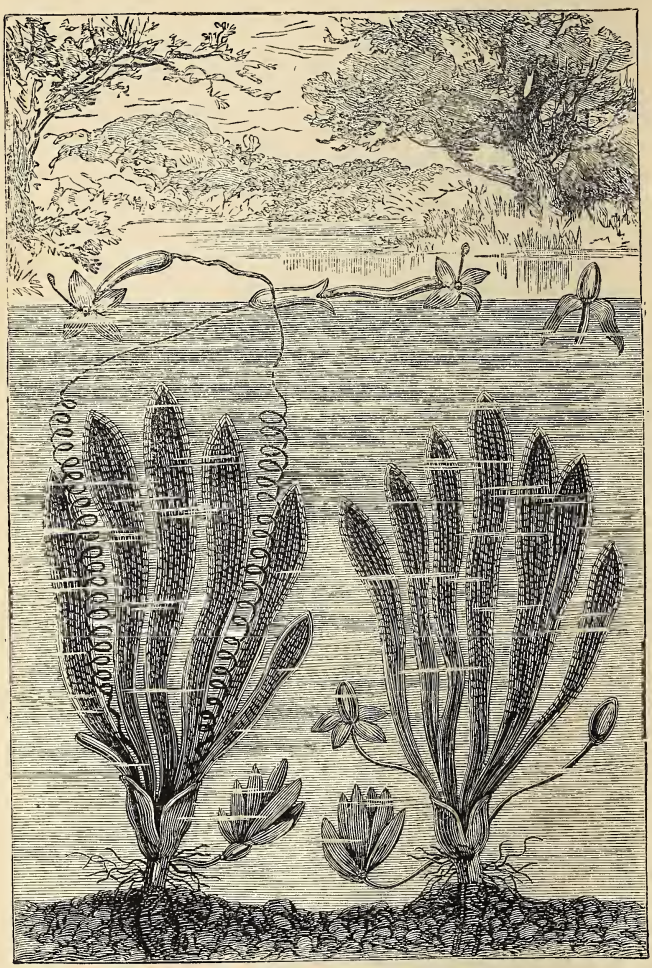

Frontispiece. FRUCTIFICATION OF VALLISNERIA. *See page* 164.

THE MICROSCOPE

AND ITS LESSONS.

A STORY OF THE INVISIBLE WORLD;

WITH

PICTORIAL DESCRIPTIONS OF ITS INHABITANTS.

BY

JAMES CROWTHER,

AUTHOR OF "THE HORSES OF THE SUN," ETC.

Wood section, magnified sixty-four times. Drawn from nature. See p. 265.

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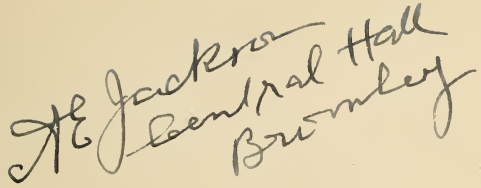
"It is truly a most Christian exercise to extract a sentiment of piety from the works of Nature. Our Saviour expatiates on a flower, and draws from it the delightful argument of confidence in God. He gives us to see that taste may be combined with piety, and that the same heart may be occupied with all that is serious in the contemplations of religion, and be, at the same time, alive to the charms and loveliness of Nature."—CHALMERS.



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THE MICROSCOPE AND ITS LESSONS.

CHAPTER I.

INTRODUCTION.

"I have seen
A curious child, who dwelt upon a tract
Of inland ground, applying to his ear
The convolutions of a smooth-lipped shell;
To which, in silence hushed, his very soul
Listened intently; and his countenance soon
Brightened with joy; for murmurings from within
Were heard, sonorous cadences! whereby,
To his belief, the monitor expressed
Mysterious union with its native sea.
Even such a shell the universe itself
Is to the ear of Faith."

WORDSWORTH.

WHEN David wrote the nineteenth psalm he directed the reader to the stars as a revelation of God's handiwork; and, after pointing to their silent eloquence, he led the reader to the other revelation, in which similar perfection would be discovered. This inspired poem is divided into two nearly equal parts, and is suggestive of the twofold revelation that God

has made of Himself—one appealing to the senses, and the other to the soul.

It is about three thousand years since that hymn was written, and what astonishing disclosures have been made since then! And it is not too much to say that, amongst all the instruments which have led to greater revelation, the telescope and the microscope are the chief; for with the one "a sun has been discovered in every system, and with the other a world in every atom."

These two magnificent keys have opened the doors to new worlds—have thus unveiled the secrets of the sky and sea, the firmament above us and the earth around and beneath us, as well as the mysteries of life within us; and he who is the fortunate possessor of a really good telescope and microscope, with the knowledge how, not only to use, but to apply for the use of others what he has had revealed to him, may surely claim to have "done the state some service."

He who wrote the poem already referred to has, in another place, given us three thoughts enwrapped in one expression. He first declares that "*the works of the Lord are great;*" then, secondly, that they are to be "*sought out;*" and, thirdly, by "*those that have pleasure therein;*" and the pleasure and profit the author of this little volume has derived during thirty-five years' study have suggested to him the duty and privilege of offering to others a sip from the full cup which has been to him a sweet source of joy that no man can meddle with, and a healthy stimulant to true devotion.

"The heavens declare the glory of God." A remarkable assembly took place at Paris about four years ago, when fifty-five delegates, representing fifteen different nationalities, took part in the investigation of the star-dust of heaven, with a combination of result that

makes us wonder what science may yet reveal to us. Many years since, the statement appeared to me to be incredible that certain parts of the heavens had been photographed; and that, whereas, on the negative, nothing but a mere blank appeared, upon the application of the microscope it was shown to be literally "powdered with stars." When, afterwards, I pointed my own telescope to a clear space in the firmament, upon which not a single star was visible to the unaided eye, and discovered a vast number, quite incalculable, of microscopic points, the whole resembling a sheet of blue paper over which a quantity of flour had been scattered, I became a convert to the theory; but what was *that* to the combined result of the Parisian astrographers of 1887? Their object was to set on foot preparations for the cataloguing of over twenty millions of stars, and to prepare a celestial map—a catalogue, as well as a chart, of the same.

The united experience of these star-gazers disclosed a mass of figures overwhelming to an ordinary mind, since by the application of photography to astronomy it was discovered that myriads of stars, whose mighty distances not even the highest powers of the telescope could reach, were by the camera portrayed on sensitized silver under the regulating influence of light. Thus the sun, at a distance of 92 millions of miles, can have its glorious portrait faithfully depicted in the one hundred thousandth part of a second. How greatly sensitive this metallic plate is, under the influence of starlight and chemistry combined, may be understood, when we are told that the maximum effect of a luminous object on the delicate nerve of the human eye is produced in the one-tenth part of a tick of the clock, that is, of a second; that beyond that limit there is continued effacement and renewal. I mean that directly the object brought to the

eye has been telegraphed to the brain by the optic nerve, the black pigment has absorbed the remainder of the image, and that marvellous window of the soul is ready for more work.

Amongst the countless host of the heavens there is a constellation known to astronomers under the sign of "Cygnus," the Swan. Fifty years ago, Sir John Herschel wrote that one of the stars in this constellation was among the most interesting he had seen. Its motion is so extraordinary that Arago supposed its velocity to exceed that of Mercury—the most rapid body of our solar system—sixty thousand times. The distance of this swanlike group of stars known as Cygnus is stated to be 657,700 times the radius of our earth's orbit, or nearly 6272 billions of miles.

Supposing one of these distant worlds to be in a state of conflagration, we should know nothing of it until a ray of light reached our eye which had started on its journey, travelling at the express rate of 192,000 miles every second—ten years before we beheld it. To make this more intelligible, a cannon-ball, rushing through space at the average rate of five hundred miles an hour, would require 14 millions of years to reach that star. So insignificantly minute is the reflection of this atom, that the delicate thread of a spider's web placed before the eye of a spectator, supposing there to be one at this star, would conceal from his view the whole orbit of the earth, the diameter only of which is nearly 200 millions of miles, the circumference nearly 600 millions; but what is our earth to the solar system?—the whole of which might be hidden from the eye of the supposed spectator by a single hair!

But what has this to do with the assembly at Paris? Much every way. Formerly this stellar witness to the

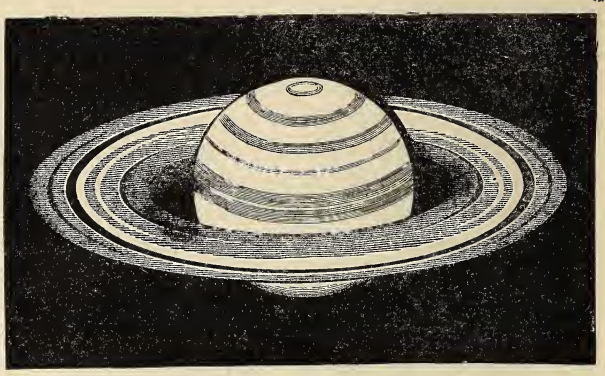
almightiness of God was declared to be composed of a cluster of 170 worlds; by the new stellar photographic process no fewer than five thousand are "clearly imprinted."

After many years of close observation, our astronomers succeeded in making a great map of the Pleiades, referred to in perhaps the oldest book in the world, the poem of Job. That map numbered 671 stars, though to our unaided eyes there would appear but seven; by the new system of stellar photography 1421 are visible. Thus it appears that stars may be photographed which the telescope fails to discover, but which the microscope reveals after the subtle influence of light has been united to the mysterious power of chemistry; and in this way it is said that seven thousand nebulæ, or clusters of stars, have been discovered already.

David was quite correct, then, when he sang, "The heavens declare the glory of God."

But what will the reader say if I tell him that I am informed by a living authority of undoubted credibility * that he had an astro-photograph, taken by one well-known observer (Mr. J. Roberts), and examined by another (Professor G. Darwin), on a small plate, covering an area of only three inches and a quarter, which, on a careful examination, was found to represent such a number of stars for the area it imprinted, as, if held to be the type of the distribution of the stars throughout space, would show the existence of 175 millions? But this was an exposure of one hour only; there have been exposures, he says, for four hours *with an ever-increasing number of star-disclosures on the plate so exposed.* So that it is only fair to say, he adds, that there are at present within the reach of man's vision as many or more stars

* Dr. Dallinger.



Saturn, as seen with the telescope.

Jupiter, as seen with the telescope.

in space than there are human inhabitants upon the globe!*

I have referred to the new life, a life within a life—may I be allowed to call it a holy of holies?—which the discoveries of the telescope and of the microscope have afforded me during what I consider the best part of my long life; and now, having nearly reached its close, with what deep and heartfelt thankfulness can I look back and recall the many splendid opportunities I have had and tried to use for the good of others in setting forth the glory of God in the exhibition of His works, saying to my younger friends, what I would say still, "Go and do thou likewise"!

"Teaching, we learn;" and if we will but use the little we begin with for the good of others, we shall find assuredly that that little will gradually increase.

How have I revelled when bringing out my telescope to show my friends that wonderful belt of light which surrounds the glorious planet Saturn, which is ten times further from the sun than the earth is, and ten times the earth's diameter; or, turning the instrument on to Jupiter, revealed that world of light, the largest in our solar system, whose solid contents are no less than 1428 times that of our earth, and whose path round the sun requires upwards of fourteen of our years for it to journey,—that is, that our earth makes $11\frac{6}{7}$ revolutions round the sun in the time that Jupiter takes to complete one such revolution! And when Jupiter's four moons, with its zones and belts, opening and closing, through which the body of the planet may be seen—as may the sun through its spots—what exclamations of delight were expressed!

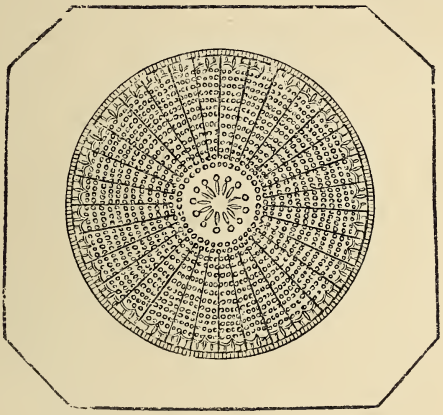
Then, having the microscope in readiness, directing

* The population of the globe is generally estimated to be 1400 millions.

Part of sun-spot, under a very high power.

A drop of water seen through the microscope, greatly magnified, showing various forms of animal and vegetable life.

attention to the live-box, in which one tiny drop of water, not larger than a very small pea, disclosed the presence of myriads of living things, many requiring a magnifying power of a million superficies to reveal the mystery of their tiny lives; or, turning to that marvel of creation, the skeleton of one of the smallest of plants, the Arachnoidiscus, showing upwards of a thousand markings on its spider-web face, attention was directed to the perfection of the Architect,—then, what notes of exclamation!



Arachnoidiscus, drawn from nature.

These contrasts in nature bring with them, to a devout mind, the strongest evidence of the power and majesty of Him with whom we have to do, who, most wonderful of all revelation, has condescended to describe Himself as "our Father;" but, alas! how different is the experience of too many in the exercise of the same privilege! One whom I know has lately told me *his* experience in working with the microscope. He is, he says, getting tired of his work. If he has for his companions in study any more advanced than himself, they only

make him look stupid, as he imagines, in *their* estimation; and if he has others with less light than himself, they look stupid in *his;* then they all get sleepy and wearied with each other.

"Well," says my favourite author, "there is no harm in being stupid, so long as a man does not think himself clever; no good in being clever, if a man think himself so, for that is a short way to the worst of stupidity. If you think yourself clever, set yourself to do something; then you will have a chance of humiliation." *

The door to knowledge is open to all, but there must first be a disposition to enter. The things which are temporal are parables of the things which are eternal. "If any man's will is to do His will" (the Syriac of a well-known text), "he shall know of the doctrine." † I have heard of a farmer who, complaining to a brother farmer of the "sourness" of his land, was advised to sow it with salt, that is, cover it with it; he did so, and the result was an abundant supply of mushrooms, the spores of which must have been long deposited either in the earth or in the salt, but in either case they only wanted to meet to produce growth.

Descending from the infinitely great to the infinitely little, I am naturally led to what the late Dr. Carpenter calls, with much reason, "the revelations of the microscope." Truly they are revelations; but of what? and of whom?

Dr. Dallinger says that no instrument in the hands of science had reached a higher perfection, endorsing the late Dr. Lankester's statement, that it was "the most perfect instrument in the world."

It is most encouraging to an amateur scientist to find so great a man as Dr. Dallinger adopting precisely the

* Dr. George MacDonald, in "Mary Marston." † John vii. 17.

same means in interesting a large audience that I have adopted for many years—descending from star-dust to earth-dust. One of my own earliest experiments, as characteristic of the almightiness of God in little things, was with the chalk which abounds in my own neighbourhood. Weighing out exactly one grain of this material, finely powdered, I counted in it 4066 separate fossils; a fourpenny piece I found to weigh just twenty-nine grains;

Foraminifera, with sponge spicules. Five different forms composing chalk, the average weight of each of the former being only the $\frac{1}{4066}$ part of a grain.

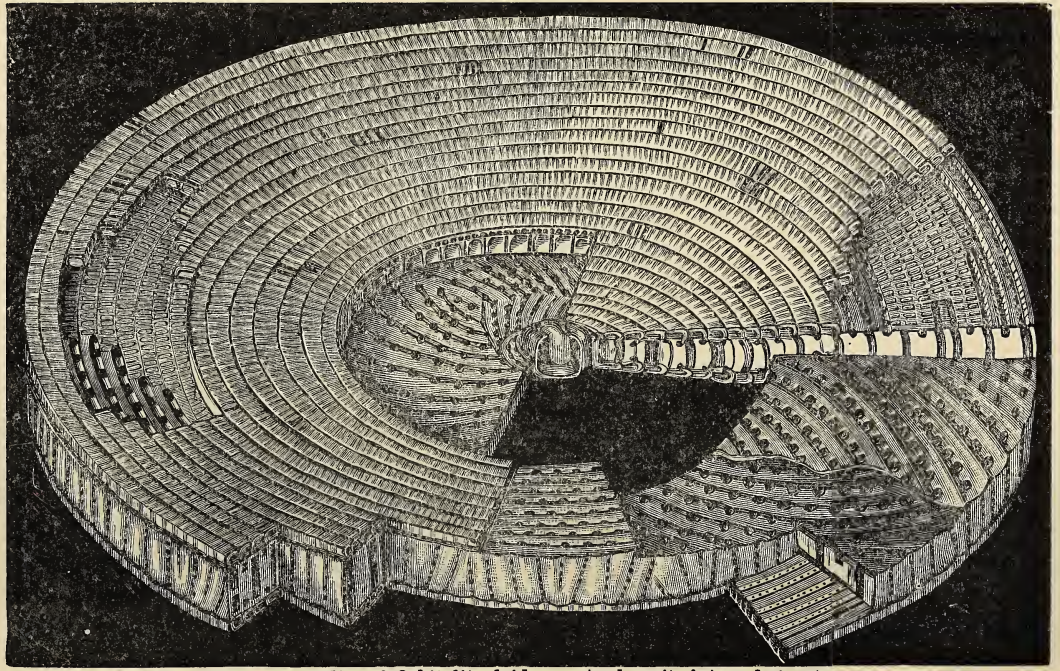
so that 117,914 of these animal animals, which once inhabited the primeval seas, weighed no more than my fourpenny piece. By an easy calculation, it was found that one pound weight of this powdered chalk, therefore, would contain 28,462,000 fossils. The learned doctor has amplified this fact.

In one ounce of chalk from a tropical coast he reckoned four millions of these lovely shells. In the deep-sea beds, by the voyage of the *Challenger*, it was proved that, in one square mile, there must have been sixteen tons of these living creatures called foraminifera, their variety and beauty being very wonderful. Sixteen tons! How many would go to a ton of *these* living bodies, if between 28 and 29 millions of their skeletons, *when filled up with chalk*, weighed, in my experience, one pound?

Fossils from the chalk.

To give some idea of numbers, and the difficulty of comprehending high figures when we get beyond a million, Dr. Dallinger states—and a remark made to me while writing this chapter, by one who knows him personally, may be here mentioned, namely, that he "takes nothing upon trust or hearsay"—that, if a man were to count as fast as ever he could beyond a hundred, so as to avoid multiplicity of words, he could never exceed ten thousand in one hour. At this rate, counting night and day, without any time for sleep or food, he would take four days and four hours to count a million. But suppose he were required to count one million a million times over—that is, a billion—it would take him ten thousand years to do it.

Should any reader care to know the mystery of a "*billion*," I would advise him to consult the late Henry Bessemer's curious calculation in my "Horses of the Sun," pp. 125–127, in which are several elaborate illustrations, set forth in a manner suitable to any ordinary mind, and very remarkable in their results.



Section of disc of Orbitolite, laid open to show its internal structure.

The learned authority, already referred to, now the President of the Quekett Microscopical Society, is very eloquent upon the fossils which compose the great chalk strata, and his clever photographs of recent foraminifera faithfully delineate their great beauty; but no words can describe exactly the wonders of their structure. Our cut represents a greatly enlarged specimen of one of the typical and composite forms of the family—the *Orbitolite*, split open to show the internal structure. Dr. Carpenter, writing of this wonderful object, says, "Discs of a comparatively minute size (from the diameter of an ordinary-sized pin's head to that of a small pea) are to be found in almost all foraminiferous sands and dredgings from the shores of the warmer regions of the globe, and have been long known as a very abundant fossil in the Paris basin; from the quarries of which stone is taken for the erection of the large buildings in that beautiful city."

Thus have I introduced the reader to "The Microscope and its Lessons." The *information* it contains will be drawn from the natural objects chiefly in my own collection; the *lessons* to be learned will be only such as would commend themselves to any ordinary intelligence. I *dare* not hide from my readers the reflections which a long and very careful study of the works of God have produced both in my heart and my head,—my emotions, that is to say, as well as my intellect; and I am fully convinced that we glorify Him when we are the willing instruments of expounding the beautiful parables—not "beautiful myths," as one has called them—He is always teaching in the phenomena of what we call "nature." Nor do I remember a greater compliment paid me—though it was not intended as such—than when one said of me, "Oh, he doesn't care for natural history unless it illustrates religion!"

I like that story which tells us how the gospel was first introduced to the natives of the Sandwich Islands, where, in 1778, our Captain Cook was murdered—illustrative as it is of how valuable a knowledge of the application of nature-teaching is in religious life; and the relation of this story will prepare the reader for the *lessons* he may expect to meet with in the following pages.

The want of a good supply of water was a terrible scourge to these uncivilized people, who, in my early life —that is, considerably more than half a century ago— were downright savages, as any one may see if he look into the faces of their idols exhibited in our national museum. Their greatest earthly want was drinking-water, and when the Christian missionary first landed, he, too, felt the same inconvenience; at last it occurred to him to sink a well in his own garden, there hoping, at the sea-level, to get fresh water. The people, never having seen a well in their lives, came to the conclusion that he must be quite mad, and imagined the world upside down, indeed, to think of *digging* for water down in *the dry earth.* Every day they gathered round and watched him digging, though they were too much scared to render any help. At last their old chief, who was more civilized than the rest, spoke. "You must be mad, missi" (missionary), he said; "rain comes from the clouds here; it does not rise out of the earth."

Day after day went by; but at last, at a depth of thirty feet, there were signs of a spring.

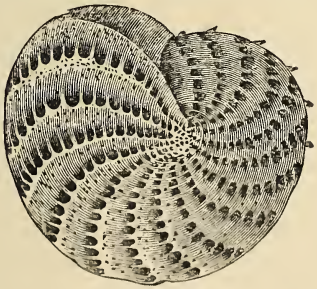
Then the missionary told the savages that the next day they should see water. On the morrow, in fear and wonder, they came, and at thirty-two feet deep, lo! there was a spring of fresh water, which has ever since supplied that particular island.

It was *this* which finally conquered the savages. The

chief gathered his people about him, and said, "We thought the *missi* mad when he said he would go down to the earth and find rain; but he has wrought and prayed till Jehovah has given it him. *Now*, as there was water in the earth beneath, so do I believe there is a God in the skies above; and as the *missi* has removed the earth and we have seen the water, so do I feel that death will remove the mist which is before our eyes and we shall see God. Bring out the idols, and let us destroy them!"

This has been the result of my own experience with both the telescope in the examination of worlds in the sky, and the microscope of the worlds within the world we call earth; for in each there is a sensible revelation of that Supreme Being we call God, and as He speaks to me through them, I would speak for Him in declaring His greatness, joining Addison in his hymn on the glories of the heavens—

"What though in solemn silence all
Move round this dark terrestrial ball;
What though no real voice nor sound
Amidst their radiant orbs be found:
In reason's ear they all rejoice,
And utter forth a glorious voice;
For ever singing, as they shine,
'The hand that made us is divine.'"



One of the foraminiferous group (*Polystomella crispa*), considerably enlarged.

CHAPTER II.

PERSONAL REMINISCENCES.

"Human experience, like the stern-lights of a ship at sea, illumines only the path which we have passed over."—COLERIDGE.

TALKING past a respectable shop in a great city some time ago, and, like many others, being attracted by the display of the pretty things exposed for sale in its windows, I said to the master on entering, "It is quite a temptation to come in here;" when he quietly replied, "Yes, the secret of our business is to *create* new wants, not to *supply* them."

That is a maxim I have endeavoured to practise all my life, and which I sincerely desire to practise still. It is good for the mind as well as the body that we leave off with an appetite. "The joy of existence is that there is so much to learn," and the chief object I have in writing these pages is that I may stimulate some of my readers, should there be any that need it, in the pursuit of knowledge, and help and encourage them in its constant application. And surely, to a mind rightly constituted, no happiness can be greater than that which arises from the consciousness that it has been instrumental in advancing the happiness of others.

There are some minds beyond one's reach. I remember once arguing with a man on the revelations which the microscope made, and he coldly made answer, "he shouldn't care for it unless it magnified the balance at his banker's." Others are incredulous, considering you are an enthusiast, and "nothing more,"—forgetting that nothing great can be accomplished in which there is no enthusiasm; forgetting, too, that enthusiasm means "inspiration," and that inspiration is indissolubly associated with revelation. In what follows, it may be that, in reviewing the records of many years, old scenes will be revived and old stories remembered, some very likely to provoke a smile, I hope not ridicule. To begin with one of these stories, let me—in reminding him of the discovery of the spring in the Sandwich Islands many years ago, and what the result was—tell the reader something about the wording of our title-page, how it came about, and what it led to.

When I first began my microscopical studies I could find no rest until I taught others. I commenced with lecturing to the young men amongst whom I worked as the superintendent of a Sunday school. My first lecture was entitled "The House Fly and the Garden Spider." I had some excellent diagrams drawn from the various objects I began to collect. The attempt was singularly successful: I was greatly encouraged. Since then—that is thirty years ago—in various parts of London and the country I have delivered about a thousand lectures upon various branches of natural history,—a labour of love in which I have freely given what I have so freely received. And if I thus speak of myself, it is only that it may be for the example and encouragement of others who may work in the same profitable field, who will find, as I have found, unquestionably, that if we know God in nature

and acknowledge and glorify Him in His works by declaring His goodness and greatness, He will recompense and glorify us in every condition and position of the life in which He has placed us.

Once upon a time the young men of a literary institution, in connection with the aristocratic neighbourhood of Belgravia, invited me to give them a lecture upon some subject which would replenish their funds: the secretary said that if I could give them an attractive title there would be a large paying attendance.

I had done this for the poor in the workhouse, for the deaf and dumb, and the blind, but this would be my first appearance amongst the Belgravians.

I accepted the invitation.

Now, it happened that exactly at that time "the Brothers ——" were exhibiting their so-called supernatural manifestations, in which they professed to have dealings with the spirits in the invisible world. Many were their dupes who, paying a guinea each, were deluded with the belief that, in the darkness of the room where the *séances* were held, they really were spectators of what was going on in another life. My friends, you see, wanted a sensational title to attract the public and enrich their treasury, so I gave for my subject—

"THE INVISIBLE WORLD;

WITH PICTORIAL DESCRIPTIONS OF ITS INHABITANTS."

Admission One Shilling.

My diagrams I took care to arrange before the doors were opened, and the secretary said, when the end came, "We thought it was all over with us when we saw how you were going to treat the subject; but——!" The

animal, vegetable, and mineral worlds were fairly represented in the pictures, and the result was a laugh—a friendly adieu, and—a replenishing of the treasury. But I have left the best for the last. To prove the truth of my description of the circulation in a leaf, I took with me my microscope, and, when the lecture was over, I showed this deeply interesting object to a select few of the visitors, amongst whom was a venerable minister– a dear old man, with a face like that of an angel. Falling in love with him at first sight, I said, "Well, how did you like my story?"

"Very much," was the reply; "but——" (oh, that little word "b-u-t," how much it sometimes includes!), "but how many superlatives you used!"

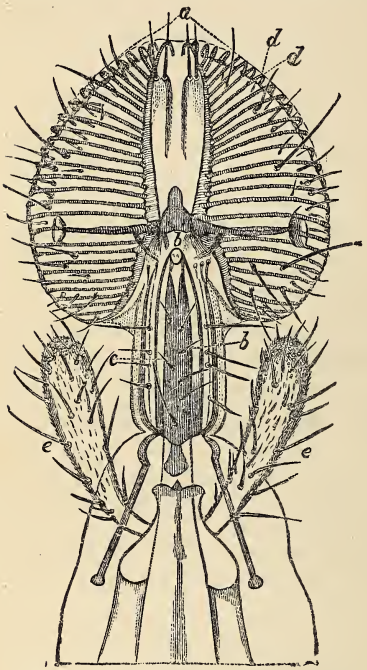
"True," I answered: "who can help superlatives, as you call them, when speaking of the works of the Most High? Now, my dear sir, come and see, and tell me what *you* have to say about the circulation in the leaf now under my microscope."

He looked at it, then at me; then the dear old eyes, which long since have had something better to look upon, looked brightly around, and when I said, "Well, what do you think of it?" "Think!" he answered, "why, I think it's perfectly *ravishing!*"

"Well, come now," I exclaimed, "who ever heard me use such a 'superlative' as *that?*"

On another occasion I was explaining to a friend the wonders of my favourite object, the tongue of the house-fly. He was one of the many unbelievers I have had to deal with. He wouldn't believe what he couldn't understand; and I made a convert of him very speedily with my silent tongue of *Musca domestica.* When the exhibition was ended, "Well," I asked, "how are you now?" "Perfectly *flabbergasted!*" was the exclamation. Then I

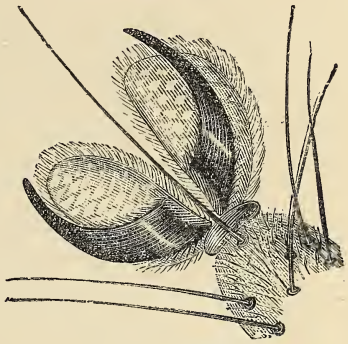
showed him the wonderful feet, with their hooklets and suckers, and he was more astonished than before. Singularly illustrative of the impression made upon the mind by only one well-used opportunity of witnessing some of the objects in "the Invisible World," let me amuse the reader with one result of my friend's experience. Many years afterwards he told me of a dream he had, in which there may be more matter for consideration than I must impose upon the reader. My friend's dream was this. He had gone home to dinner on his fiftieth birthday, and after it was over, seated in the conservatory smoking his pipe, one of his daughters, climbing upon his shoulder, caused the tobacco-smoke to get into his eyes, while she remarked, "She did not know another man who, at his age, had so few grey hairs." In the course of the evening my name occurred in the conversation, which—after the exhibition just mentioned, namely, the wonders of a house-fly—my friend always associated with the microscope. And these four things, namely, the smoke, the grey hairs, the instrument, and myself, all got



Tongue of the house-fly (*Musca domestica*).

a, terminal sucking disc; *b*, aperture leading to gullet; *c*, lancets; *d*, trachea; *e*, maxillary palpi.

so jumbled up together in his mind during the night, in his sleep, that he dreamed he had me under a microscope, and could not succeed in focussing me because I was smoking a pipe and blew all the smoke into his eyes!



Foot of house-fly.

From a course of so many years in exhibiting the microscope to people at various social and other meetings, it will easily be believed that many amusing stories might be recalled; one or two may serve to afford another smile. At one I was exhibiting my favourite object, the aforesaid wonderful tongue of the house-fly. In the company forming an evening *soirée*, there were two ladies who had evidently come to be seen rather than to see. They looked down my magic tube, and one said, "What may this be supposed to be?"

"That," said I, "is *supposed* to be the tongue of a house-fly."

"Oh, lor!" she exclaimed, "what a horrid thing!"

I, supposing she had altered the focus, good-naturedly replied, "Perhaps you have not seen it properly. Allow me to move the stage."

The slide was a very good one, but, like its owner, rather old-fashioned. The object was encircled with red paper, with a small scrawl printed in gold, and by an accident, and in ignorance, I managed to place, not the object, but the gilded paper, under the glass, and, supposing it was a better view of the tongue, "Now," said I, "perhaps you will see it better." I think

I see that *person* now, as, calling her friend, she exclaimed, "Oh, Elizabeth, come here—here's a lovely thing!"

Once, at a lecture in the country, having the worthy vicar for a chairman, a very broad-speaking Scotchman, when all was over, and he expressed to the people his satisfaction and astonishment at what he had heard, he said it reminded him of what happened in his country, on one of the lakes, when the first steamboat appeared upon the water. An old Scotch woman, who had never seen a steamer, and knew nothing of its motive-power, put up her hands in amazement, shouting, "Eh! the works of God are great, but this beats 'em all!"

At a working-men's meeting one evening I learned a lesson never to be forgotten; and I mention this in the hope that should this book fall into the hands of any one engaged in teaching, he or she may never be discouraged should either often appear to "toil all night and catch nothing." We *do* leave—we cannot help leaving—an influence behind us, for good or for evil, every time we speak,—*that* is my belief. From this meeting of working-men I came home much discouraged. What did *they* care for plants and flowers? Not a bit, it seemed to me. I had my diagrams nicely exposed, but, when the lecture was ended, feeling vexed, I rolled them up and came home. Not many days after, a City missionary called upon me, and said—

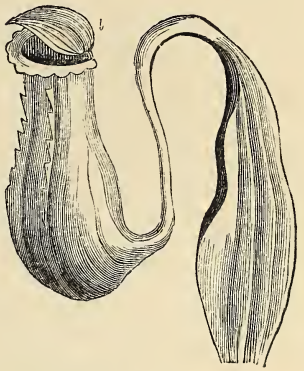
"You gave a lecture a short time since, sir, to the working-men at ——?"

"Yes," I replied, "I know I did. What about it?"

"Well," he answered, "there was one man there who was an atheist, and your illustration of design in the story of the pitcher-plant has made him very uncomfortable, and he asked me if I would beg the favour of his coming to see you."

"*Made him uncomfortable!*" I exclaimed. "Would that I could make others so. By all means tell him to come; I shall be delighted to see him."

Well, the man, dressed in his Sunday best, came, and I found myself, for the first time in my life, face to face with an intellectual fellow who had the—what? *heroism?* no! *cowardice?*—no!—*foolishness?* yes! to say there was no God. And this is about what transpired that evening as we sat down together.



Single leaf of the pitcher-plant (*Nepenthes*).

p, winged petiole, which becomes narrowed and then expands, so as to form the pitcher by being folded on itself; *l*, the lid, open, formed by the blade of the leaf and joined by a hinge to the pitcher.

"You see, sir," he began, "my father would not believe in a God, and I was taught to believe that what was good enough for him was good enough for me. But I have never been happy. I have often wondered, as my business exposes me to danger, what would become of me in case of sudden death, and your story of the wisdom and goodness of God as shown in the designing of that pitcher-plant has made me more uncomfortable than ever; and I have come to ask you, if there *is* a God, how may I find Him?"

What followed I may leave the reader to imagine. He came again, and the result must be left to Him whom he had so recently denied.

A similar, but less serious story may be told of another meeting of working-men. I was illustrating and endeavouring to prove the existence of a Designer from the fact of design meeting us very strikingly in insect

life; and, that night, I was specially devoting an hour upon the structure of my little friend, the honey-bee. I had one or two diagrams to make all plain, and, when it was over, I said to the men, that if any wished for further information I should be pleased to give it, or to chat with them upon the subject; and I particularly addressed myself to one man, saying, "Well, how did *you* like my story?"

"Oh," he said, "I liked it very well; but how about that bee's leg?"

"Well," I replied, "what about that bee's leg? You don't believe it, I suppose?"

"No, sir," he answered, "I shouldn't like to say *that*."

"Why not?" I rejoined. "I never expect everybody to believe all *I* say. But, come now,—next week, all well, I shall be here again, and *then* if you don't believe when I show you, with the aid of the microscope, the real leg of a bee with the pocket open and the spring in its place to keep the pollen from falling out —I won't say what I think of *you!*"

Hind leg of the honey-bee, with the bread-pocket open.

Next week came, and, remembering that one should never know the meaning of "trouble" when good has to be done, I took my microscope, and again met the workmen, and, at the close, I showed my friend the bee's leg. He had said something to justify his incredulity on the previous occasion about the story being very "*queer:*" now, it was *my* turn; so, watching him closely as he looked upon the object, I quietly said, "Very pretty, isn't it?" But the man made no answer; he

first looked down the microscope, and then at me, and only said, as he gave my hand a firm grip, "All right, sir; good night!"

Now, my friend, if you should be so happy as to be a teacher (but, stop! "*IF*"!—we are all teachers, and cannot help it), here's a lesson for your encouragement.

Weeks after this, a dear friend came up to me, saying, "Oh, I say, Crowther, what *have* you been doing?"

"Doing!" I answered; "many things. Why?"

"Well," he said, "there's a man employed in Deptford dockyard, and he's going about amongst all the men talking about nothing but 'Crowther' and bees' legs!"

Sometimes a different result has attended the labour of love, but often spiced with what may reasonably provoke a smile, although it be of graver sort.

Once, after a severe affliction, when I was over-sensitive and easily unnerved, I received an enigmatical letter from a very dear friend, whom I truly loved and would not wound for the world—a clergyman, who had formerly been my pastor. He lived at some distance. I said to myself, "There's something between the lines in this mysterious note, and I shall have no peace till I know what it means; I shall go and find out for myself." Reaching his London residence, I found him absent. I stayed till he returned, and then we had some such conversation as this: "My dear Mr. A., you have written me a note which reads like a mysterious riddle. There's more in it than is expressed—what is it? What have I done that appears to have offended you?" "Oh, nothing *very* particular," said he, "nothing *very* particular; only—only—that lecture you've been giving at Mr. Spurgeon's——!"

Now, the truth was this: I *had* been giving one of my entomological talks to the children at Stockwell, belonging to Mr. Spurgeon's orphanage, and a favourable report

of it found its way into the newspapers, and my friend had been reading the same. When I discovered the key to the riddle, I fear I was *rather* naughty as I remembered the unrest my good friend's note had occasioned me, and I said rather sharply, "Mr. A., I was called to give the lecture at Mr. Spurgeon's Orphanage, and I went; and I would go and lecture on a dust-heap if only I thought I could do any good on it." "Yes, dear Crowther," said my friend, with a seraphic smile, "that would be all very well, provided only it were a Church of England dust-heap!"

Many other curious results, ending in the production of these books—this forming the tenth volume—might be mentioned. One, the best of all, must close this chapter, which may have been too *selfish.*

Eight or nine years since, while staying at a very dear friend's house in the most lovely part of Kent,—where, for many years, I had been in the habit of lending a helping hand in instructing the people in a handsomely furnished lecture-room, which my large-hearted friend had built,—he said to me, "It is a great pity you should not publish your stories. What is to become of them, when you are gone?"

"Ah," I said, "no one would care to read such lectures as mine."

"*Wouldn't they?*" he replied. "*I should!*"

On my way home I thought it over, and the result was that, having the very highest esteem for the Sunday School Union, for which I had many times lectured, I made the committee the gratuitous offer of all my stories, to be rewritten by myself in a popular form, so that they should make a readable book for the public, and at the same time contain the matter necessary for the lecture committee to continue the stories with my own diagrams

as illustrations, when I shall have other work to do in heaven, or be unfitted to continue the work on earth.

This volume is the last of the series; the first, "The Five Barred Gate," published in 1881, I am glad to see, has reached a sixth edition.

A few illustrations of ridiculous misprints in advertisements and reports of these stories may close this chapter on personal reminiscences.

Imagine my horror, then, one evening, on entering a lecture hall at the West End, the subject being the "Life and Adventures of a *Gnat*," to find large posters on the doors, announcing the subject as "The Life and Adventures of a *Goat!*" What a difference may one single letter make!

In a lecture once given at Chichester, a long report of which attracted my attention in the *West Sussex Gazette*, where I said the cockchafer had 8820 lenses, making so many *bundles* of compound microscopes, the report made out that I had stated them to be so many "*bushels*" of microscopes.

"The *Horses* of the Sun" was very recently noticed by a Reviewer as "The *Houses* of the Sun."

Lastly, let me say that some of my best and dearest friends are those gained in the pursuit of my favourite study; a study, for the great privilege of enjoying and pursuing of which I desire to thank God with my whole heart. It has been to me—and, my reader, may it be to you—an introduction to a new world,—a world, I mean within a world,—bringing with it a gradually increasing accumulation of true riches; leaving always a thirst for more, with the assurance that, if we see God in all His mighty works here, we shall see all His works in Him, no longer "through a glass darkly," but face to face; and let us never once forget that while we are looking into

what we may call the secrets of "the invisible world," we are looking, through them, up to Nature's God; and let us listen to the beautiful words of a modern writer who says, "If you would listen to Nature's wonderful tales, or see her marvellous treasures, you must not trifle with her; you must not talk as if you rummaged her drawers and cabinets as you pleased. You must believe in her; you must reverence her; else, although she is everywhere about the house, you may not meet her from the beginning of one year to the end of another." *

And then, when the end is coming, and we look back upon a well-spent life, as we stand on the border-line of two worlds, we shall be reminded of the beautiful lines of an old writer—

"Clouds of affection from our younger eyes
Conceal that emptiness which age descries;
The soul's dark cottage, battered and decayed,
Lets in new light through chinks which time hath made."

* Dr. George Macdonald.

CHAPTER III.

ENTOMOLOGICAL.

"In these beings [*insects*], so minute, and as it were
Such nonentities, what wisdom is displayed,
What power, what unfathomable perfection!"

PLINY (A.D. 60).

COME, then, and sit with me while we busy our minds over the exceedingly little things of nature; and, while we travel through pleasant fields of study together, let us never forget the many lessons they were intended to teach, since "all matter is radiant with spiritual meaning," and the Great Teacher is still educating every devout mind with parables.

Do you ask me to explain our instrument, and tell you about its cost and power of magnifying? Well, first you may have a tolerably good microscope for about five pounds—good enough, that is, to begin with. Remember, the value of the glasses depends not so much upon their magnifying power as their power of penetration and definition. The human eye is, perhaps, of all the senses, the easiest to educate; and constant practice with the low powers—that is, those which magnify *least*—will strengthen the sense of vision, and gradually prepare the eye for the higher powers. The glasses we shall presently

use will vary from what is called a four-inch objective to a sixth inch: these are terms used by the makers to denote the focal distance of the field-glass from the object. My lowest power, the four-inch, with the "A," that is the lowest eye-piece, magnifies only ten diameters—that is, one hundred superficial times. True, it is only a "magnifying glass," but it may be greatly increased at the upper end with other eye-pieces, till, with the fourth eye-piece, it may be brought up to thirty-two diameters, or 1024 superficial times. This glass is invaluable to the lover of flowers. If I show you a blossom of mignonette you will never forget it; while, looking into the indescribable beauty of a heartsease will astonish you. I have found the most useful of all the glasses to be a good three-inch with the use of the drawer-tube and the deeper eye-pieces; but we shall need all our object glasses in the delightful work before us, and I must not stop to weary you with figures, for which probably you have no interest. Our lowest magnifying power, I have told you, costing thirty shillings, will only magnify at the most 1024 superficial times; our highest, a so-called *sixth*,—that is nominally a sixth of an inch from the field-glass to the object,—with the deepest eye-piece and the draw-tube extended, will give us fully nine hundred diameters—that is, about a million of superficial times. "Good eyes see light through the smallest chinks," but your eyes would require to be educated that you might know how to appreciate these wonderfully perfect specimens of magnifying glasses. I have found the lower powers and the draw-tube to be the most useful, I repeat, for educating the eye. I have frequently been told that I could see more with my one eye than others could with their two; but everything depends upon the right management of light, in which we shall find our first "lesson."

Dr. Carpenter rightly calls the microscope a *revelation.* Every Bible-reader knows who it was that once said, "I thank Thee, O Father, Lord of heaven and earth, that Thou hast hid these things from the wise and prudent, and hast revealed them unto babes;" and who that knows anything practically of *that* revelation is ignorant of the fact that "*Light! light! more light!*" is the constant cry of every devout student, and that "the True Light, that lighteneth every man, has come into the world," and is the Sun of Righteousness?

The so-called bull's-eye lens for transmitted light, the mirror for reflected light, and a good spot-lens for dark-ground illumination, with the lower powers, and condensed light with the higher, are the chief instruments necessary in the management of light; and with these, in practised hands, wonders may be done. But, I will not tire your patience with what, I fear, may have no interest for you, but at once introduce you to our cabinets.

You will remember that in the "séances" of the so-called spiritualists there was a *cabinet* in which the cheat was "got up;" no light, of course, was *there;* all the cleverly contrived tricks were performed in the dark. *Our* "séance" is made clear with light, either natural or artificial. We shall see the truth of that saying that "all things are made manifest by the light, for whatsoever doth make manifest is light."* We may and shall have difficulty in comprehending some of the figures connected with the measurements of several of our higher class of objects. Were *all* truth made perfectly clear to my mind I should doubt the truth of its being divine. I have found the two revelations—namely, nature and the Bible—to be an exact representation one

* Eph. v. 13.

of the other. The more I magnify an object the more, as a rule, I can see; and the more I believe, the stronger my spiritual vision.

Once, in doubt as to the meaning of facts in relation to figures, it struck me that there was a short and ready way to an explanation: the figures appeared in the "Micrographic Dictionary," by Messrs. Griffith and Henfrey. I knew nothing of the authors personally, but it occurred to me to *go direct to them* * for an explanation; I did so, and I received it almost by return of post.

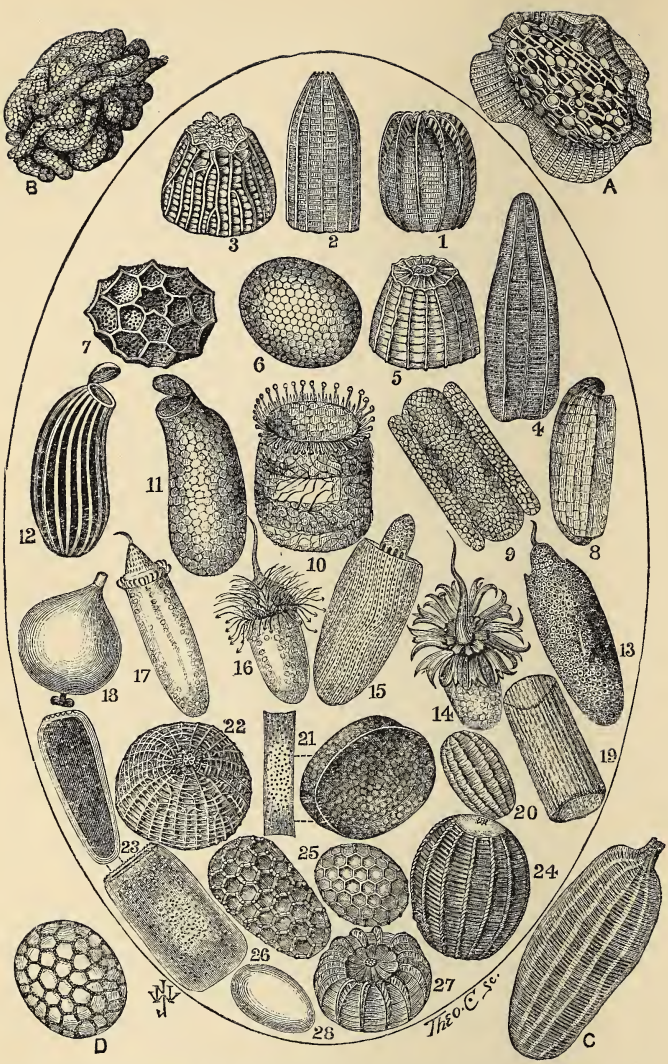
What a lesson for the Bible student is taught in this simple story!

The Dictionary above referred to is, perhaps, the most valuable that has ever been written upon the microscope. It contains upwards of seven hundred pages, and is illustrated by upwards of forty full-sized and beautifully engraved plates, each containing very many figures, besides about nine hundred wood engravings.

The Introduction covers forty pages, giving a full description of the instrument and its apparatus, the best way of managing the light, and the general method of determining the structure of the various objects before us, the cost of which objects varies from one to twenty shillings each—the best investments I have ever made. Here are sections of the tongues of flies and spiders, cats and dogs, and, of course, human tongues; all parts of the human body, internal and external, from the hair on the head to the nail on the toe, from the optic nerve of the eye to the nerve of the foot and the skin of the heel, the brain and muscle, bone, and teeth,—all are here, awaiting our examination.

Flowers and leaves, fruit-stones and wood from all the wonderful variety of trees,—seeds of all kinds from various

* See John vi. 68.



Comparison of eggs of insects with seeds of plants (see p. 94). Drawn from nature by W. J. Norman.

parts of the world,—are here, carefully numbered and classified, requiring the long life of a Methuselah to study them all.

And here, too, are geological specimens of various strata: from the Himalaya mountains, the Mounts of Olives and Sinai; also of the Pyramids of Egypt and the Vocal Sphinx, and from the old primeval forests of past ages, with their curious contents of fibre and spores; as well as curiosities of chemistry and photography—the choice collection of thirty years. Are you willing that I should be your guide? I have many valuable credentials; much experience; some enthusiasm, devotion, and love both for my favourite study and the happy work of bringing it to the notice of others; and thorough sympathy with David's words, "Thou, Lord, hast made me glad through Thy works, and I will rejoice in giving praise for the operation of Thy hands."

But, in the short time we shall have at our disposal, you must only expect to have "a sample of the bulk," as business men say. I shall have done something for your good, my imaginary companion, if I can so reach the source of your hunger after knowledge, as to make you leave off with an appetite; and you will discover that sixty minutes over the microscope will make very considerably less, apparently, than one ordinary hour.

Where *shall* we begin?

Life begins with the egg; so, as it is best to begin at the beginning, let us begin with the eggs of insects.

What beautiful things they are! Whatever God does is always done well. See, here are the eggs of a nocturnal moth, *Noctua nigrum*. To what shall we compare them? minute domes, they are ribbed from the centre to the bottom, and almost exactly resemble the echinus shell.

These eggs once enclosed the caterpillar of a stint-bodied moth, which is said to assume the colour of the lichens on which it feeds, being grey when it feeds on a grey one, and yellow when it feeds upon a yellow one; the change of colour being intended by Providence, it is supposed, to conceal it from its enemies, as it is very difficult to distinguish it from the lichen upon which it is feeding.

Have you ever thought what wonderful things eggs are?—of the variety of colour, as in those of birds; their beauty of design, as of insects; and their remarkable resemblance to seeds?

"It was a notion of [Erasmus] Darwin's," says Rennie, "(much more plausible and ingenious than his metamorphosis of shell-fish into birds), that the colours of many animals are adapted to concealment from their natural enemies."

May we not see in this one of the many parables of nature? Is it not a riddle which any devout student will easily discover?

The suggestive remarks of many celebrated entomologists respecting the change of colour in the caterpillar as it varies its food, applies to several species in the variety of colour in its egg; in several cases it is precisely similar to the part of plant upon which the egg is laid. And then, too, how regularly and orderly they *are* laid! not deposited anyhow, one upon another, but neatly and beautifully packed side by side, as with rule and compass.

The eggs of insects have a thin transparent shell enclosing the germ of the caterpillar, exactly as the seed encloses the embryo of the plant; and a comparison of one with the other will give us much matter for reflection on the beginning of life in animals and plants. Both

contain a supply of food stored up for the young, which is gradually exhausted as the young develop. The carbo-hydrates and nitrogenous materials in the seed are consumed by the young plant just as the yolk of the egg is consumed by the hatching of the chicken.

Some insects lay an incredible number of eggs. Many people are heard to exclaim, "Where *do* the flies come from? Bother the flies!" Let us follow the calculation of a student of this branch of natural history,* who tells us that Mistress *Musca domestica*, the common house-fly, for example, deposits eighty eggs at a sitting, and that she performs this operation four times during her life; and he shows, in a curious table, how, in one season, one single female may thus be the progenitrix of upwards of ten millions of flies!

You must see the eggs of some of the parasites which infest various animals, and you will be surprised at their beauty and variety. Now compare the egg of the house-fly with that of the domestic bug; the former is exactly like the exquisitely carved ivory boxes of the Chinese, while the latter glitters with exquisite chasing as on mother of pearl.

You will change your mind, I think, when we come to our story about the house-fly's enemy, the garden spider, if you think there is nothing to admire in the latter. But let us dismiss this brief reference to the beauty of insects' eggs by taking a peep at those of a spider. You will observe that they are perfectly round, without any of the external sculpture which renders the egg of an insect so beautiful. Remember that the spider is not a true insect any more than a scorpion is; both belong to the same family, but more of that presently.

The germ of spider-life in the egg appears in the

* Keller, quoted by Samuelson.

form of a minute white point immediately under the shell, and in the centre of the circumference. I have a story for you respecting the hatching of spiders, which will illustrate and, I hope, justify the title page of our book, in respect of the "lessons" which our microscopical studies are calculated to teach.

My friends have inundated me with presents of one kind and another, and I may truly say with Dr. Watts—

> "Not more than others I deserve,
> Yet God hath given me more:"

and, among them, a lady once presented me with a spider's nest, taken from its place of concealment in her garden. It was that of the *Epeira diadema*, the common garden spider. It was taken in the time of winter, months before, in the natural order of hatching, the young would have been produced; and the bag was cleverly concealed by the mother in a snug nook in the garden fence. I put the nest, or egg-bag, into a small box, which, all the cold winter day, I carried about in my pocket, and, in the evening, I proceeded to examine its contents with my microscope. To my surprise, I discovered that the heat of my body had hatched the eggs, and some were broken. I counted one hundred and seventy perfect eggs, most cleverly packed in a bag of silk—not your common web, such as the creature spins to entrap insects, but genuine silk of a different sort. I put one of these tiny eggs in my live-box, and observed the nucleus through the thin shell, the diameter of the nucleus being one third the entire egg, the remaining two-thirds being the yolk and white, very like that of a fowl. I estimated the size of each egg to be about one-sixtieth of the size of the head of a doll's pin. In a former work * I have told

* "Solomon's Little People."

how, at the conclusion of this experiment, I was astonished to find, secreted at the bottom of this cleverly contrived nest, the body of a fine fat blue-bottle, which the self-denying mother had concealed for the purpose of affording food for her numerous family until they were strong enough to find their own food, she no longer being in the land of the living; but I have not there told the result of an experiment I made that evening with one of her artificially hatched babies, so I will complete this story while we are looking at our object.

I put one of these little creatures, born in my trousers pocket remember, in the live-box, and watched the beating of its pulse, and I counted thirty-five pulsations to the minute, against my own fifty-eight.

Whether from heat from the reflection of the lamp through the condensing lens, or from confinement, or excitement, I cannot tell; but I know that, while my own pulse increased, being not a little delighted with my experiment, my baby's pulse rose from fifty-eight in the minute to 150! I laughed at the idea of feeling a spider's pulse; but when I read, afterwards, that Hunter, the celebrated anatomist, was similarly employed in counting the pulsations in the body of my little friend, the house-fly, I considered I followed good example in an interesting experiment.

You know, of course, that the first form of the living insect, when liberated from its prison-house, is the caterpillar. Here is a very fine specimen of the larva of the Vapourer moth. Let us look first at *larvæ*, then the *pupæ*, then the *imago*.

If you have read the volume preceding this, on "Solomon's Little People," a story about the ants, you will not need to be reminded that these scientific terms signify, first a *mask* (it doth not yet appear what the thing, so

formed, is to be); then a *pupa* or *mummy*, which it very much resembles; and lastly, an *imago*, that is, a *perfect image* or representation of the creature.

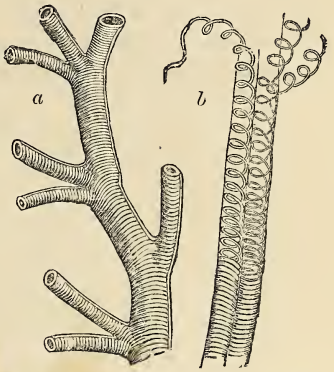
First, let us examine the eggs of the Vapourer—a common moth, whose care for her young may teach many a mother a lesson; for, out of the warm pupa-case from which she has escaped so recently, she contrives to make a silken bed for her young. Here they are; look at them. Could you have conceived such perfection? Observe how they are fastened to each other in neat and orderly fashion. "This custom of fastening the eggs to the web in a constant method is so peculiar to this species of insect, that I have never observed it in any other kind; like a prudent housewife she never leaves her habitation, but is always fixing her eggs to the surface of the web, out of which only a few days since she made her escape." *

No doubt this is to keep them warm in winter; and it is suggested that, the bed being made of silk, its non-conducting property, both with regard to heat and electricity, must be of great benefit to the concealed embryo in the egg, in preserving it during the winter, in the branch of the tree where it may have been deposited.

Now look at the baby larva with its six legs, with which you may have seen it feel its way as it fastens on to the tree on which it feeds with the other ten. Observe, the fore legs are altogether different to the hind legs (also called claspers); one minute hooklet terminates each of the former, and about fifty each the latter. This enables the creature to hold on securely while it feels its way from leaf to leaf. But look at the forest of hairs, which cover its body, bristling up like an armoury of spears; and there at the mouth, is the opening of the spinning-machine

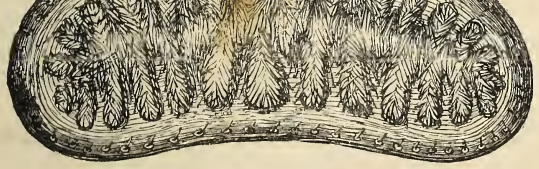
* Swammerdam, quoted by Rennie.

with which it works the silk, made from vegetable matter, which once suggested to a thoughtful Persian the beautiful proverb that "time and patience will convert the mulberry leaf into satin." This is a typical caterpillar, and we must content ourselves with its study, though a large family await our examination.



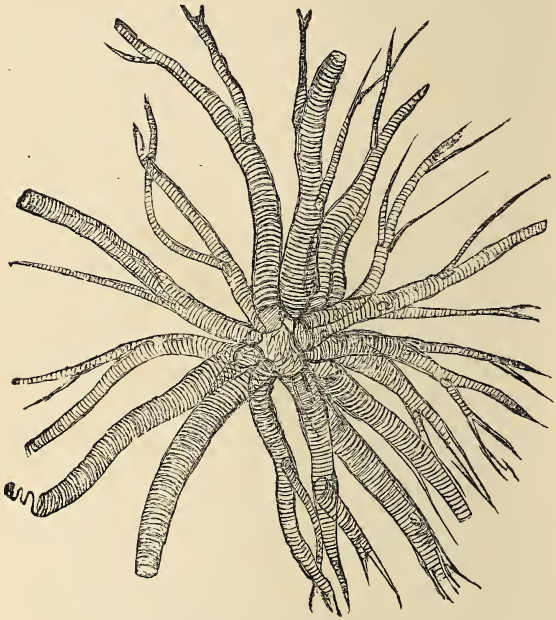
Tracheæ of an insect (*a*) compared with spiral vessels of a plant (*b*).

Observe its exquisitely formed tracheæ and spiracles, the organs through which it receives the outer air, passing through its entire body. What care has been bestowed on these tiny openings—called "spiracles," from the Latin *spiro*, "I breathe"—running along the sides of its body! There are six pairs, and there is reason to believe they open and shut just as our lungs contract


Spiracle of *Dytiscus* (water beetle), greatly enlarged.

and expand every time we take in and give out the air we breathe. But what a marvellous display of wisdom is here! Look at the tracheæ—so called from the Greek for "windpipe." Coils and coils of fibre secure a safe

passage right down to the end of the tongue of the perfect insect, keeping the long air-tubes from collapsing, and providing a safe passage for the life-giving air, which would appear to be sifted from all impure substance before entering the body by the sieve-like spiracle,



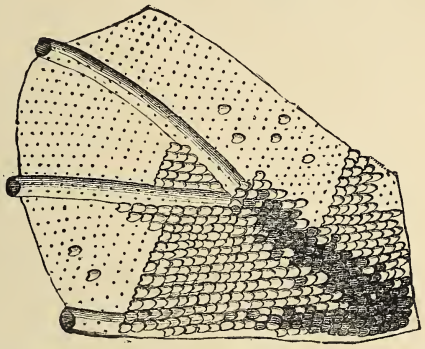
Tracheæ of a beetle.

and then, when thus purified, supplying this humble creature with the first element of life.

Now behold the pupa, which, observe, has just escaped from the very admirably contrived pupa-case. It is no stretch of the imagination to call this empty cell a coffin, and the "*transition*" a veritable resurrection. There are the shrivelled remains of life number *one* attached to the

shroud in which it was buried, in part composed of the silk made from its own body; and, because it needed strengthening, you see, just as we mix cotton and silk in one fabric, so is it here. This cocoon is made partly of silk, produced from leaves by digestion, and partly from the curious hairs which it must have removed from its own body previous to what we call "death."

Now for the imago! What a sight! "Do you mean to say this splendid moth, with its countless featherlike scales on its four exquisite wings, and its branched an-



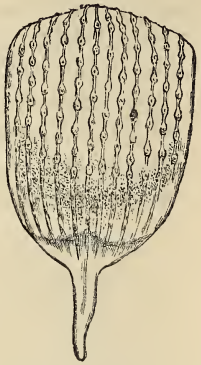
Portion of the wing of a moth, showing the points where the scales were removed.

tennæ, having two hundred joints in the pair, each joint of which is covered with hairs, invisible to our eyes without our instrument—that *this* wonderful thing came from *that* empty tomb?" You may well ask the question. Quite true, indeed it is; but is it not strange, being true, that so little is seen in the sublime lesson it teaches? and do you not think I truly have described this section of the cabinet, "*Resurrection at Sight*"?

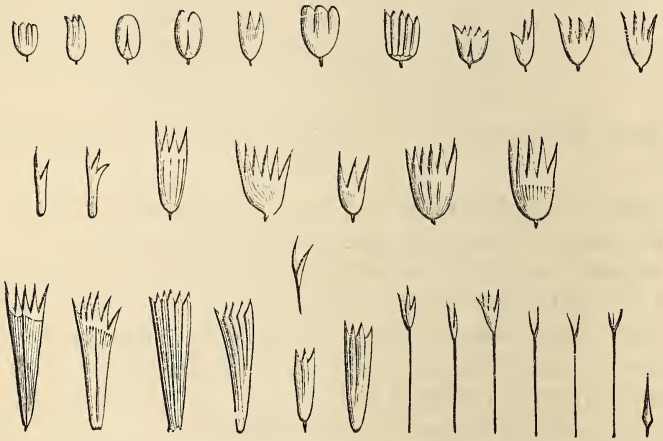
Of course you know that these scales are to the insect just what feathers are to the bird—organs of flight; and

one is just as wonderfully constructed as the other. Do

Scale from wing of *Morpho Menelaus* (butterfly).



Battledore scale from wing of *Polyommatus Argus* (butterfly).



Various forms of the scales of butterflies.

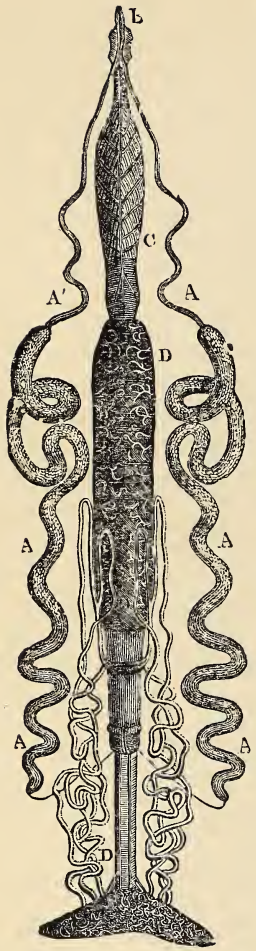
you know that there are about four hundred thousand of

these exquisite scales on the wing of a butterfly, all so beautifully marked—I had almost said *sculptured*—that the very highest powers of our instrument will be necessary to detect them? Dr. Royston-Pigott, F.R.S., says, as an example of delicate measurement, the focal thickness of one of these butterfly "feathers" was, by the aid of a colleague, three times measured at the 1,250,000th of an inch.

Here is the choicest entomological specimen I have seen in any one's cabinet, showing what human ingenuity can accomplish, and illustrating the truth of the proverb about time and patience. It is a bouquet of flowers, in an exquisite vase, around which a group of gay butterflies are apparently enjoying themselves. There are fuchsias, roses, and, for a centre, a sunflower. And all this beautiful, although artificial arrangement, consists of nothing else whatever—flowers and leaves, vase and flies—all arranged, remember, according to their natural colour—but the dust, or scales, or "feathers," whichever you like to call them, taken from the wings of insects, the total number of scales amounting to twelve hundred.

You observed the mouth of the caterpillar of the Vapourer, where the two openings of the spinning-machine were, from which the fine silk was drawn out which formed the raw material for its coffin, when it passed into its intermediate state. Let me now show you the secreting organs, which will open your eyes, I hope, to the revelation of God in this humble creature, and remind you of the words of an old writer,* who, had he the optical advantages you and I possess, would have used stronger language than he did: "It is not only," he says, "in the creation of the heavens, of the earth, of the sun, and the sea; of elephants and camels, horses'

* Jerome, A.D. 380.



Secreting organs of the caterpillar.

AA, silk secretors; A′, their excretory ducts; B, the spinneret; C, throat; D, stomach.

and oxen; of tigers, bears, and lions, that the Creator is to be admired. He is not less great in the production of the smallest animals, such as ants, flies, gnats, and other insects which we know better by sight than by name. The same power and the same wisdom are remarkable in all."

This admirably contrived spinning-machine here shown will apply to that of the common silkworm moth caterpillar, and will enable us to draw your attention to the extreme fineness of the material which is converted from the mulberry leaf into satin.

A communication to the Society of Arts by Miss Henrietta Rhodes, not very long since, and sent to me by a scientific friend, stated that one line of the silkworm when unwound measured 404 yards, and, when dry, weighed three grains. Hence it follows that one pound avoirdupois of the thread as spun by the worm may be extended into a line 535 miles long, and that a thread which would encompass the earth would weigh no more than forty-seven pounds.

Curiously spiny is the caterpillar of the peacock butterfly, the perfect insect having remarkably

beautiful spots—all, remember, formed of nothing but a countless host of "feathers," so small as to measure only the 1,250,000th of an inch in thickness—which give to it the name of "peacock." The underside of the wings is very dark, and, when they are closed over the back, the fly looks more like a flat piece of brown paper than an

Peacock butterfly.

insect; but when this "child of the sun" is feeding with its glorious wings unfolded, what blessed thoughts does it suggest as it reminds us of Rogers' beautiful lines—

> "Yet wert thou once a worm, a thing that crept
> On the bare earth, then wrought a tomb and slept;
> And such is man, soon, from his cell of clay,
> To burst a seraph in a blaze of day!"

Our next object shall be an ant, fancy it so dissected that all its muscles are to be seen, by which you may learn how it is that this little model of perseverance can accomplish such astonishing feats of strength. I need not do more than describe to you the object, having told you all I know of ants in "Solomon's Little People," but I may tell you a useful story I recently heard of an ant. Its home had been broken up, and in the crash its leg was broken. It was a nurse, and had the charge of the babies, and, though it could only crawl along with difficulty, it never forsook its charge; and this poor wounded creature actually succeeded in carrying away *ten* of the baby ants to their new settlement before the repairs were completed. Learn from this that, however weak or unfortunate we may be, there is always something, either in service or suffering, that we can do for the good of others.

Now observe its muscular structure. Muscles! Do you know that the body of a caterpillar I had presented to me one day, that of the great goat moth, contained about ten times the number of muscles that were to be found in my own? It led me a pretty dance. Coming to me carefully imprisoned in a deal box, I laid it on our hall table, and, shortly after doing so, I was about to experiment on the creature, when, on opening the box, to my surprise, it had discovered the weakest part of the wood, and had eaten its way through. I hunted everywhere, and, several days after, I found it snugly concealed in the seat of a sofa, in a room separated from the hall by a number of stairs and a long passage: it had sixteen legs, and it knew how to use them—but its muscles!

Lyonnet, the famous entomologist, counted 228 in the head, 1647 in the body, and 2186 around the intestines, giving a total of upwards of 4000. To the right use of these muscles may be ascribed the amazing strength of this singular caterpillar, which generally builds its tomb in the willow trees.

The author of "Insect Transformations" gives a striking description of the uses to which these four thousand muscles were once applied in the removal of a body very many times its own weight. "We put the caterpillar of the goat moth," he writes, "under a bell glass which weighed nearly half a pound, and of course more than ten times the weight of the insect, yet it raised it up with the utmost ease. We then placed over the glass the largest book we had at hand, 'Loudon's Encyclopædia of Gardening,' consisting of about fifteen hundred pages of strong paper, and weighing four pounds; but this did not succeed in preventing the escape of the animal, which raised the glass though loaded with the book, and made its exit."

In the human body there are about four hundred and fifty muscles; in the proboscis of an elephant forty thousand, 'tis said,* but how many in the proboscis—that is, the tongue, properly speaking—of a butterfly! Here is one, it is that of the sphinx genus—the Convolvulus, a hawk moth, which, after feeding upon green leaves in its first life, in its perfect form sips the nectar contained in the bottom of the cup of flowers. One of these moths, in the act of feeding upon the flowers from which it takes its name, is represented in our cut. Nothing in all nature surely can be more suggestive or illustrative of human life than the metamorphoses of this creature—one of the largest of our garden caterpillars: its grave, made by itself, as

* Cuvier.

well as the coffin in which it lies concealed, in a striking manner will remind us of Longfellow's beautiful lines—

"There is no death—what seems so is transition;
This life of mortal breath
Is but the suburb of the life elysian,
Whose portal we call 'death'!"

The Convolvulus Sphinx.

But, reminding you of what has been said of muscular power, do look at this wonderful tongue of the Convolvulus Sphinx. Compared with the forty thousand in the proboscis of an elephant, how incalculably greater is the number of muscles in this sucking-pump, which measures from three to four inches in length—and it is only one half of the tongue either, for this half folds on to, and into, the other half, the two conjoined forming a tube down which

A family visit.

the sweet nectar is received into the insect's body, the two halves, when laid open, presenting the most wonderful and beautiful object, properly illuminated, that can be conceived. Take a common white butterfly, and, holding it gently in your left hand, and, making good use of your eyes, look towards its head; then, with the right, take a pin and begin to uncoil the watch-spring-like coil which is rolled up in the front of the head; *that* is the proboscis, similar to that I am now showing you.

Proboscis of butterfly.

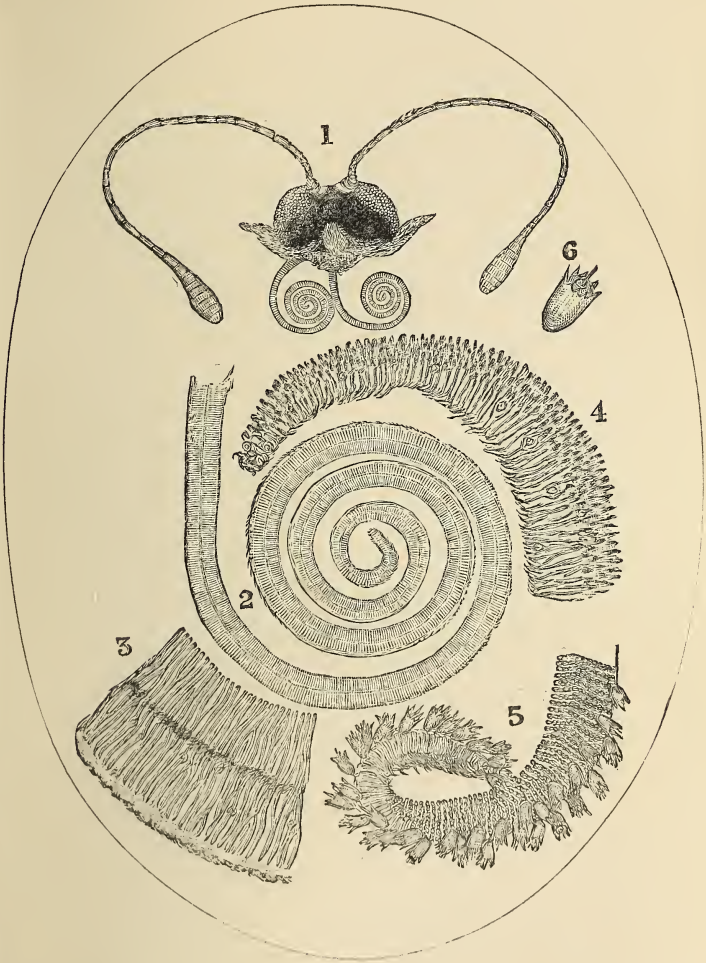
When visiting the family of a scientific friend some years ago, "My children," said he, "have something to show you." Presently, what they had to show me consisted of a cigar-box turned into a butterfly's house, the front covered over with thin gauze, the removal of which revealed the tenants. The children proceeded to feed their pets with saccharine matter; and they unrolled their long sucking tongues, and feasted before me for my special entertainment and instruction.

Nothing of this extremely complicated tongue-like or pneumatic machine appeared in the *first* life—the caterpillar of the creature; still less in the entombed chrysalis. The sharp mandibles of the mouth answered every purpose in the animal's former life, which mandibles, or jaws, were just as different to this wonderful sucker as a pair of pincers would be to a watch-spring. Surely it

is evidence of *design*, and of the care of the Creator for the supply of the wants of so humble a thing as a fly, rather than the "fortuitous concourse of atoms," which, happening to fall together, as some advocates for evolution would lead us to believe they do, produced such a marvel of workmanship as this!

To what different conclusions do both Kirby and Spence and Rennie arrive in their admirable works on entomology; to these experienced and popular authors I would refer the reader for the most reliable information in his entomological studies; each and all are allowed to be first-class expositors of insect life.

In his work on "Insect Transformations," in the chapter on "The Generation of Insects," Rennie writes that "Darwin, taking the hint from Epicurus, fancies that animals arose from a single filament or threadlet of matter, which, by its effort to procure nourishment, lengthened out parts of its body into arms and other members. For example, after this filament had improved itself into an oyster, and had been by chance left dry by the ebbing tide, its efforts to reach the water again expanded the parts nearest the sea into arms and legs. If it tried to rise from its native rocks, the efforts produced wings, and it became an insect, which in due course improved itself by fresh efforts till it became a bird, the more perfect members being always hereditarily transmitted to the progeny. The different forms of the bills of birds, whether hooked, broad, or long, were," he says, "gradually *acquired* by the perpetual endeavours of the creatures to supply their wants. The long-legged water-fowl in this way acquired length of legs sufficient to elevate their bodies above the water in which they waded. *A proboscis*," he says, "*of admirable structure, has thus been acquired by the bee, the*

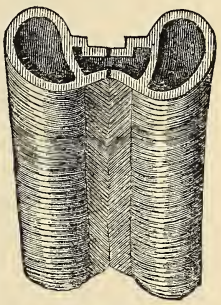


Different forms of butterflies' tongues. (See p. 94.)

moth, and the humming-bird, for the purpose of plundering flowers." *

I desire to call your special attention to this wonderful tongue, because it is as fully demonstrative of design as the setting together of the type of this book. It is composed of two filaments, fastened together by a curious seemingly mechanical contrivance.

The celebrated naturalist, Réaumur, tells us that the section of this proboscis discloses three small rings, and that there are three canals in the trunk, and in his inquiry as to whether these three were used in sucking the juice of flowers, suggesting the idea of the suckers of a pump, he says, when taking the portrait of a moth while sucking a lump of sugar, "I held in one hand a powerful magnifying-glass, which I brought near to that part of the trunk I wished to examine; I was sometimes half a minute, or nearly a minute, without perceiving anything, after which I saw clearly a little column of liquid mounting quickly along the whole length of the trunk. Often this column appeared to be intersected by little balls, which seemed to be globules of air which had been drawn up by the liquid. This liquid ascended thus during three or four seconds, and then ceased. At the end of an interval of a greater number of seconds, or sometimes after an interval as short, I saw some fresh liquid mounting up along the trunk. But it was straight up the middle of the trunk that it seemed to ascend.



Section of proboscis of moth, highly magnified.

* Darwin's "Zoönomia," 1801, quoted in Rennie's "Insect Transformation."

"The Author of Nature has given to insects means of working which, though very simple, we cannot divine, and which often we are not even able to perceive. Whilst I was observing the trunk of our butterfly, between the columns of liquid which I saw ascending, there were times when I saw, on the contrary, liquid descending from the base of the trunk to the point. The descending liquid occupied half or two-thirds of the tube. It was no longer difficult to perceive how the butterfly is able to nourish itself on honey, the thickest syrup, and even the most solid sugar.

"The fluid it sends down is very liquid; it drives against the sugar, moistens, and dissolves it. The butterfly pumps this liquid up again, when it is charged with sugar, and conducts it along as far as the base of its trunk, and beyond it."

Amongst all the wise sayings of that deep thinker, Dr. Macdonald, none is greater, in my opinion, than this: "Until we see God as He is, and are changed into His likeness, all our beliefs must partake more or less of superstition; but if there be a God, the greatest superstition of all will be found to have consisted in denying Him;" * and as that other deep thinker, John Foster, says, "He who explodes His laws, denies His existence." †

As I have already told you, having devoted some time to ants in another work, I will only now remind you of the remarkable use these little "people" ‡ make of their brains, as illustrative of the best uses which big-brained animals may make, by the right application, of theirs; and the anecdote I will use will remind us of another—about an elephant who once left the waggon he was drawing, and whose keeper supposed he had bolted

* From "Paul Faber." † Foster's "Essays."

‡ See Prov xxx. 25.

into the woods through which they were passing, when, presently, to the driver's surprise, the big-headed brute returned with a huge branch of a tree, which he had broken off, using it to thrash his fellow, who would not do his share of pulling the load over the road they had been passing.

In all the remarkable stories told by Sir John Lubbock about ants, and which he has kindly authorized me to repeat, I know of nothing in reference to instinct that can surpass the following. I can fully believe the truthfulness of the story, however incredible it may appear, having witnessed a similar scene in my own garden. I take it from the cutting of a periodical sent me by an anonymous friend, who only wrote outside, "From one interested in your lectures." It is headed—

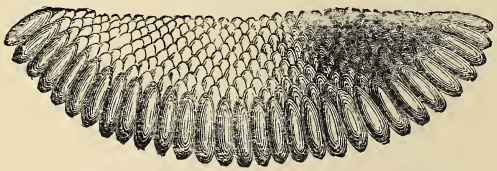
"Funerals among Ants.

"There are ants which bury their dead, a fact which was discovered by accident. A lady had been obliged to kill some ants, the bodies of which lay about on the ground. Presently a single ant found its dead companions, and examined them and then went off. Presently it returned with a number of others, and proceeded to the dead bodies. Four ants went to each corpse, two lifting it up, and the other two following, the main body, some two hundred in number, following behind.

"The four bearers took their office in turns, one pair relieving the other when they were tired. They went straight to a sandy hillock, and there the bearers put down their burdens, and the others began immediately to dig holes. A dead ant was then placed in each grave, and the soil filled in. The most curious part of the proceeding was that some six or seven ants refused to assist in grave-digging, upon which the rest set upon them, and tumbled them unceremoniously into it."

I will now show you the pupa of a gnat. It is one of the most useful of all my best objects, for which I have the greatest regard. Before I ask you to see in it, amongst examples of a higher nature, an illustration of the truth I have already reminded you of, that the more we magnify the more we see, let me repeat one or two facts in the gnat's life with which, probably, you are not acquainted.

I wonder how many people know that the gnat in the first two parts of its life is aquatic—that it lives in the water? Mrs. Gnat is a boat-builder, and she knows that, although in her perfect form—that in which you are best acquainted with her—water would be death to her, any other element *but* water would be death to her offspring. So, seeking some bit of weed or any floating par-

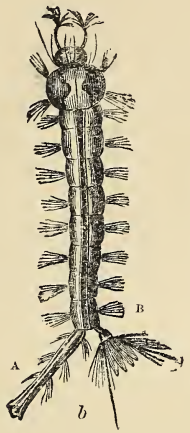


Egg-boat of the common gnat.

ticle which she may find on the pond or running stream, you may, during the summer-time, see her and her busy companions actively occupied in skimming over the water. They are seeking some substance, whatever it may be, upon which they may securely deposit their eggs. Having decided what it shall be, one after another is laid upon it, until about two hundred and forty may be counted.

Now, in what form do you think this beautiful creature has been instructed to build up its kind of floating nest for her interesting family, who are to live, remember, not as she does in the air, but in the water? Well, it is a boat; exactly in the form of a Thames "wherry"—a boat without oars, but which can never be

upset, and which can float upon the stream without injury until the vivifying sun brings them all to life. Our objects, remember, are the pupa and the larva, both intermediate states of the creature. The larva, which I will show you, bears very little resemblance to the pupa, and *neither* the slightest resemblance to the life which is to come of them. Here is a true likeness of the former (*b*), beside another of the latter (*a*).



Larva of the gnat. Pupa of the gnat.
A, entrance of the air-pipe; B, the tracheæ.

Observe at A a small pipe extended: I know only a few animals that breathe through the tail. At B is seen the commencement of the breathing-tubes, which convey the air to all parts of the body. Its chief business in life number one is to eat, it has nothing else to do; its food is whatever it can find in the water in which it lives. It throws off its exterior covering, its outer skin, or jacket we may call it, several times before it passes into its mummy form, when it becomes entirely changed. Its eating-time is now over, and the object we are looking at is that which I am describing. Not partaking of food, it has no digestive organs. Its organs of respiration are likewise changed: it has lost the little tap-like tail with which it came to the surface; yet, filling its body with air by jumping up to the surface, it repeats its leap for a similar purpose every time it needs a fresh supply, and then it breathes through the

two little ear-like appendages you may see projecting from its big head.

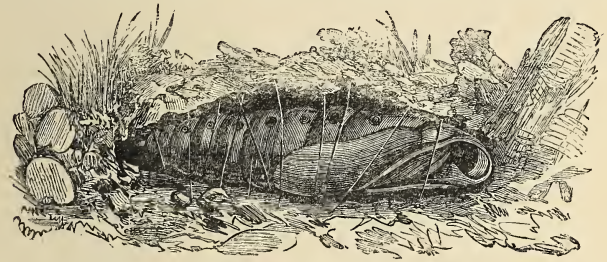
There is a crisis in its little life-history, just as there will be in yours and mine; and that crisis is when it is passing away from the life that now is to that which is to come, when it is no longer to live in water, but air. When the time of this crisis arrives, or when the time of this pupa would have arrived had it not been taken and prepared for our inspection, it would have reposed very quietly on the surface of its watery bed. In a moment its outer skin, which, in its former state, became detached from its body several times as exuviæ, would have split from one end of the body to the other, and presently the "imago," the final and perfect form of the gnat, would have appeared. This is what it has been preparing for; it is the last chapter in its curious life, and so this is what I chiefly want you to see and to think about.

Let me first tell you what happened when I fortunately came into possession of this precious object. I looked at it with a low power, and saw nothing but a big-headed creature, having nothing in particular to attract attention, and I put it into my cabinet between the larva and imago of its fellow in the division on which I have told you I have written, "Resurrection at Sight." One day I looked at this pupa with a greater magnifying power, when I no longer recognized it as the same object; I still further increased my aid to vision, when, to my indescribable delight, for the first time in my life, I saw the future life mysteriously wrapped up and concealed in the object before me.

It appeared too marvellous to be true, and as I saw the doubled-up feet, six in number, and the embryo wings, even to the minute scales (one of the test-objects for high magnifying-glasses), my heart leaped up within

me at the thoughts which rushed into my mind, as I said, "If this be not a dream or delusion, I see the phenomena of my own mortal life; for, if the 'Great First Cause' has bestowed this threefold being, and given me the privilege of seeing it typified in one of the humblest of His creatures, why may I not reasonably look within and discover the internal evidence of my own grand future, partly exhibiting itself in my spiritual longings now?"

Afraid lest my enthusiasm should carry me beyond the realms of truth, I hurried off to the mounter of my cherished object. I asked him to take down his microscope and look at it. He only employed a low power, the



"Transition:" self-buried pupa of a hawk-moth.

object being a large one. "Yes," he said, "it is the pupa of a gnat; that's all." "Increase your power," I said; when, nearly as much surprised, but not half so delighted as myself, he confirmed my belief that it really showed the future life of the gnat concealed within the pupa.

Surely there is a suggestive parable in nature as we look upon the transition in and transformation of an insect, as it lies wrapped in its grave waiting the sweet influence of the sun to awaken it to its newness of life on its resurrection morning! Verily all things "*are* double to that which is"! *

* Job xi. 6.

I came home that day a wiser, and, I hope, a better man.

May I venture to tell you what some of my reflections were? First, that if there be a future life it appeals to our reason that it must have some connection with our present condition.

In the object to which I am directing your attention, it certainly appears—doesn't it?—that everything around it and within it was preliminary and preparatory to a future state,—a segment only of a circle, and not the whole. Then, if all this wisdom has been displayed in the life of so humble a creature as a gnat, is it not most reasonable to believe that it will find its completion in the life of a man? Then naturally follows the question, If we, too, are preparing for something in a future life, should we not ask ourselves, What is it? Clearly the so-called "*death*" of the first stage in the life of the insect was not ceasing to be, but only ceasing to be in that stage. The imago—that is, the final state of a gnat's life—is the putting on of a new existence for which the two preparatory states were fitting it. The decay of the old body was *necessary* in order that the final state might be reached. The future life, you see clearly, was mysteriously wrapped up in the chrysalis, only waiting to be unrolled. The gnat received with its earliest being the germ of all that it was to be hereafter; and do you think all this would have been bestowed upon an insect and not given to a man, therefore to such as you and me?

Do you not see what splendid possibilities are within us, and, therefore, what tremendous responsibilities are around us? The whole record of our immortality is laid up within us *now;* and it is only the mortal envelope that encloses it, which prevents it being visible. But the Almighty One has lovingly given us spiritual truth in

such a sensible picture as this, and all it needs is a spiritual eye to perceive it, and a spiritual understanding to receive it.

When we arrive at such a reasonable conclusion as this, the eternal world is brought wondrously near to us, and every part of our mortal nature becomes irradiated with it, while it lifts up and adorns every sphere in which we live, and, as an eloquent author adds, some of whose thoughts I have been interweaving with my own, "whatever our place, if we are doing our work well, earth becomes the ante-room of heaven, and we are breathing in hallowed air."

There is no greater boon which God bestows upon us than these sunbright illustrations and convictions, which make the present and future life meet and blend together. He who possesses it cannot live without lifting up, every day, a hymn of praise for that existence whose line stretches, unbroken, through the endless avenues and towards the mellowing radiance of the city of God; and he cannot lie down to the last agony without feeling the strength that gives him wings to rise above it, as with the last motions of his lips he says to the world in which he has lived, "Good night." *

No better object than this shall we find that will illustrate our subject—"*a story of the invisible world;*" and no other instrument than the microscope, which is to the mind what faith is to the soul, would enable us to see it.

Now, be pleased to look at the final state of our friend. Here is a beautiful specimen of what you see marked as "The *Culex pipiens*"—the piping gnat, that is the name. Such a creature would have come from such as you have just been looking on.

* Abridged from "Foregleams of Immortality."

The great French naturalist, Réaumur, says, "The gnat is our declared enemy, and a very troublesome enemy it is. However, it is well to make its acquaintance, for if we pay a little attention we shall be forced to admire it, and even to admire the instruments with which it wounds us. Besides which, throughout the whole course of its life it offers most interesting matter of investigation to those who are curious to know the wonders of nature."

Observe the remarkable beauty of its wings, covered, in an orderly manner, with a number of delicate scales, similar to those on the moth of the silkworm, where four hundred thousand have been counted; the head presenting the most astonishing armoury of lancets and tubes, preceded by the most beautiful of plumose antennæ, and enlightened with twenty-four thousand lenses.

Surely all this will suggest to you something of the phenomena of another life, and bring to your remembrance the words with which we all are familiar, "It doth not yet appear what we shall be."

Here is a specimen of that terrible family of insects, the locusts. It is a relation of our English grasshopper; and this will enable you to appreciate the blessing we enjoy in being delivered from such a scourge as, in Africa, is still called "the eighth plague of Egypt."

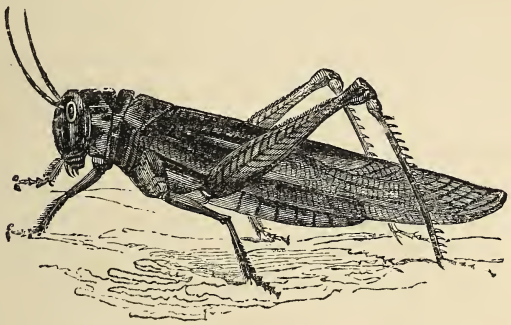
All who are familiar with country life are familiar with the chirp of the grasshopper, but, happily, all are not acquainted with the features of a live locust, because it is rarely seen in England.

Among my presents, I once had a live locust sent me, and I was struck with its remarkable resemblance to a horse; but were the strength of the horse proportionate, in respect of its size, to that of the locust, what a veritable giant would it be in the power it would possess!

Our instrument reveals to us the secret of this strength.

You see it is in the muscular power of the two hind legs: they form a solid compact mass of muscular fibre, every bit of which is a true mechanical spring, enabling the creature to make those remarkable leaps which is characteristic of the class of insects belonging to what the entomologist calls *Orthoptera*, signifying "straightwing," on account of the manner in which the under wings are folded below the upper.

I believe it was a German author who, writing about the house-cricket, described it and the class to which it



Locust.

belongs, which is the same as *Locusta*, as "praising the Lord by rubbing their legs together:" it was very true, if very strange, language. Let us compare the wing-case of the cricket with others of its family. See, here is one; it is that of the male, who uses his musical instrument, like a good husband as he is, to please his wife. On the wings of the grasshopper you may count upwards of fifty tooth-like keys, which are very similar to those on the cricket.

It seems reasonable to believe that the variety of sounds produced by insects are intended for signals to

their companions, who, of course, must possess organs of hearing.

"I will tell it softly,
Yon crickets shall not hear it,'—

these words are from our poet Shakespeare, whose remarkable acquaintance with the secrets of natural history often appears to approach inspiration. We notice these musical keys in the wing of the male cricket only, not the female,—for, as the celebrated entomologist, Swammerdam, remarks, in confirmation of Rennie's statement that "it is the males alone of crickets who are musical,—the females make no noise," but in that part of the male wing-case which is folded horizontally over the trunk, there is a round plate made of a very fine transparent membrane, resembling the tympanum of the human ear; it is surrounded by a strong and prominent nervure, concealed under the fold of the left wing-case; and Rennie, who is a most reliable authority, writing upon the subject of noises produced by grasshoppers and crickets, adds it is exceedingly probable that the quick motion with which these insects rub these nervures against each other produces a vibration in the membrane, whence the sound is augmented, so that it is literally true that crickets *do* "praise the Lord by rubbing their legs together."

A whole chapter might be devoted to this part of our story. We might tell of one who took so great a fancy to the merry chirp of the house cricket that he was accustomed to keep them, for their music's sake, in a box in his study. Some fancy they presage misfortune; others that it is unlucky to kill them: *we* prefer very much to have them silent, and nicely spread out before our eyes under the microscope.

If a chapter might be devoted to the story of our

domestic friend, the house cricket, how many might be devoted to his foreign relation, the true locust—that tropical pest, which is worse than an invading army in the devastation it produces, and which,—though, thank God, it is very rarely seen in England, and then only an accidental importation—is sometimes seen in the suburbs of Paris, but is frightfully destructive in some parts of Turkey, also in Asia and Africa.

Here is one example. The present Chancellor of the Exchequer, Mr. Goschen, when he returned from Constantinople in 1881, from his work in the city of the Sultan, whose finance, like our own, he had been endeavouring to improve, said, at a public meeting in London, in justification of his sympathy for the Turks, "I am not placing this picture before you simply to harrow your feelings; but I did wish to give you a picture of some of the troubles which were weighing upon the Turkish Empire—some of the disasters which seemed to add to the complications that were pressing on the Government of Turkey. I am sorry to say that I have not exhausted the list. A plague of locusts came on the western shores of Asia Minor and laid low the crops; only this morning I received a letter from a government officer telling me that the plague had reappeared, devastating the crops and corn—that 1700 *tons* of young locusts had to be buried in his district alone." You may examine the undigested contents of a locust's stomach, if you please, from a specimen I have recently had sent me. You will find its large capacity completely filled with parts of the bodies of insects and little bits of leaves. It was evidently a first-rate gourmand, wasn't it?

Here is a description of the ravages these instruments of desolation will make, which is confirmed over and over again by all Eastern travellers: "Wherever they alight

they change the most fertile country into a desert. They are seen coming in innumerable bands, which, from afar, have the appearance of stormy clouds, even hiding the sun. As far and as wide as the eye can reach, the sky is black, and the soil is inundated with them. The noise of these millions of wings may be compared to the sound of a cataract. When this fearful army alights upon the earth, the branches of the trees break; and in a few hours, and over an extent of many leagues, all vegetation has disappeared; the wheat is gnawed to its very roots; the trees are stripped of their leaves; everything has been destroyed, gnawed down, and devoured. When nothing more is left, the terrible host rises, as if in obedience to some given signal, and takes its departure, leaving behind it despair and famine. It goes to look for fresh food—seeking whom, or rather, in this case, what it may devour." *

In one year they covered a vast surface of Africa; when the wind blew they were driven into the sea, and their carcases occasioned a plague which laid a whole country waste.

One kind sometimes comes near to our own shore. In France rewards were offered for their larvæ, and a curious calculation has been made as to the number collected in one season, when a hundred and fifty tons of locusts were thrown into the Rhône from only three departments of France, whose numbers were estimated to have been 5250 millions—that is, nearly four times the population of the whole earth.

We, in England, are sorrowfully connected with the Arabs of the Soudan, where the good General Gordon lost his devoted life. There the Soudanese endeavour to frighten the locusts by savage yells. In the Middle

* "The Insect World," by Louis Figuier.

Ages the children of superstition in Ethiopia employed exorcism against an immense host of these destructive insects. A celebrated monk thus describes the ceremony. Having made the natives form in procession, he ordered them to sing psalms, "Thus chanting," says he, "we went into a country where the corn was, which, having reached, I made them catch a good many of these locusts, to whom I delivered an adjuration, which I carried with me in writing, by me composed the preceding night, summoning, admonishing, and excommunicating (!) them. Then I charged them in three hours' time to depart to the sea, or else to go to the land of the Moors (!) leaving the land of the Christians. On their refusal of which, I adjured and convoked all the birds of the air, animals, and tempests, to dissipate, destroy, and devour them; and for this admonition I had a certain quantity of these locusts seized, and, pronouncing these words in their presence, that they might not be ignorant of them, I let them go, so that they might tell the rest."

The Arabs are said to have an infallible method of ridding themselves of the locusts; and in relating both these stories, we may well consider how the legends of the Papacy are reflected by those of Mahomet, who one day is reported to have read in Hebrew character on the wings of a locust these words: "We are the troops of the Most High God; we each lay ninety-nine eggs; if we were to lay one hundred, we should devastate the whole world." Upon which Mahomet, who is said to have been greatly alarmed, made an ardent prayer, in which he begged God to destroy these enemies.

In answer to this, the angel Gabriel told him that a part of his prayer should be answered; and since then this answer, as a reminder, we suppose, written on a piece of paper and enclosed in a reed, is planted in a wheat-

field or orchard, which has the power of turning away the locusts.

In our New Testament we read of locusts forming human food. The Arabs still eat and are very fond of them. One was asked his opinion of the insect as an article of food. Expressing his admiration of locusts, he is reported as saying, "I only wish I had a basketful of them, wouldn't I scrunch them!" English travellers who have tasted locusts in ignorance, have owned the flavour is agreeable.

Locusts are not only mentioned literally in the New Testament, but metaphorically in the Old, and it is to the latter the student of natural history must go for a description of these destructive creatures; and especially do we meet with them in the prophecy of Joel. The darkness and gloominess mentioned by the naturalist is referred to by the prophet;* the fierceness and speed of the creatures, their noise and regularity of march, the obscuration of the light of day by their number and flight, and the consternation and distress they bring wherever they settle;—all is clearly and exactly described, although used as a metaphor.

Let any reader, who is tempted to listen to the voice of one opposed to the inspiration of Holy Writ, compare the evidence of an unbeliever with the words of a prophet, and then say what he thinks of that wonderful book we call the Bible. And first having carefully read the chapter in Joel already referred to, then let him read Volney's "Travels through Egypt and Syria." He writes: "Syria as well as Egypt, and almost all the south of Asia, is subject to those *clouds* of locusts so often mentioned by travellers. The quantity of these insects is incredible to all who have not witnessed their astonishing numbers.

* Chap. ii.

The whole earth is covered with them for the space of several leagues. The *noise* they make in browsing on the trees and herbage may be heard to a great distance, and resembles that of an *army* foraging in secret. The Tartars themselves are a less destructive enemy than these little animals. One would imagine that *fire had followed their progress.* Wherever their myriads spread, the verdure of the country disappeared, as if a covering had been removed. Trees and plants, stripped of their leaves and reduced to their naked boughs and stems, caused the dreary image of winter to succeed in an instant to the scenery of spring. When these clouds of locusts take their flight, to surmount any obstacle, or to traverse more rapidly a desert soil, *the heavens may be literally said to be obscured by them.*"

In Dr. Kitto's notes on this chapter, from which Volney's words, just quoted, are taken, there are the following words, confirming my own remark as to the striking resemblance between the locust and the horse. Referring to the fourth verse in the chapter mentioned, namely the second of Joel, where the words occur, "The appearance of them is as the appearance of horses," he writes, "The first time we saw locusts browsing with their wings closed, the idea of comparing them to horses arose spontaneously to our minds, as we had not previously met with such a comparison, and did not at the time advert to the text. The resemblance in the head first struck our attention; and this notion having once arisen, other analogies were found in its general appearance and action in feeding. We have since found the observation very common." The Italians, indeed, from this resemblance, call the locust *Cavaletta,* or "little horse." Sir W. Ouseley reports: "Zakaria Cazvini divides the locusts into two classes, like horsemen and footmen, mounted

and pedestrian, which will recall to the recollection of a biblical reader some passages from Joel and the Apocalypse." Niebuhr says that he heard from a Bedouin, near Basrah, a particular comparison of the locusts to other animals; but as this passage of Scripture * did not occur to him at the time, he thought it a mere fancy of the Arabs, till he heard it repeated at Bagdad. He compared the head of the locust to that of a horse, the breast to that of a lion, the feet to those of a camel, the belly to that of a serpent, and the tail to that of a scorpion.

If the reader will compare these remarks with the verses in the Bible, he will be forcibly struck with their family likeness; and then if he turn to the passage referred to in the Apocalypse, there he will find that the invading Arab is referred to, he whose progenitor's hands were to be against every man, and every man's hands against him. The star falling from heaven may mean the founder of Mohammedanism; and the habits and ravages of the locust are descriptive in a very remarkable manner of those of the Arabs, of which Mahomet was the chief. As "the sun and the air were darkened" by the former, so was the world filled with the darkness and error of the latter. The people of Arabia are compared to "locusts" or "grasshoppers for multitude," † for in the original the word for both is the same. If the reader, like the author, is at all interested in these references to the dear old Bible, let him compare these three descriptions of the habits of the locust with what the learned Bishop Newton so carefully and fully explains as characteristic of the Arabian followers of Mahomet, and he will find that the structure of the insect and its terrible rapacity are very remarkably characteristic of the race of Ishmael to this

* Rev. ix. 7. † See Judg. vii. 12.

very day; and he will see that not real, but figurative locusts were here intended, and he will be reminded of a similar figure in that remarkable prophecy of Moses,* where, before the children of Israel entered Canaan, the punishment which would follow their disobedience was said to be by sending the *hornet* to drive them out and destroy them, and, as we here have a carefully prepared specimen of the hornet, we may close these Biblical remarks with its examination.

Yes, it is quite true, I *do* like to associate the works of God with His Word. They are to me, exactly what the most scientific of my books are, complete in this respect, that all the letterpress is confined to one volume, and all the illustrations to the other.

Now, if you will just look on the label of our object, the hornet, you will find it marked "Vespa" this being the entomological name for the insect; but vespa is only an abbreviation of Vespasian, meaning the same thing, as "Tom" is an abbreviation for "Thomas." And was it not after the Israelites had reached the height of wickedness, when they killed the Prince of Life, that, in A.D. 70, the Emperor of Rome, Vespasian, destroyed their city, which from that time to this has never been restored to them?

The hornet is the largest European species of the family of the *Vespidæ*, to which the whole tribe of wasps belong. We may almost read the character of the Roman Emperor, Vespasian, in Webster's dictionary, where, in explaining the word "waspish," we may read "petulant; irritable; irascible; quick to resent any trifling afront:" to which he might have added, "cruel," for a greater act of cruelty was never performed by any one human being upon another than what is said Titus, Vespasian's son,

* Deut. vii. 20, compare with Numb. xxiii. 56.

433/56

performed upon a young Jew whom his daughter loved, chiefly on account of his beauty. The son inherited not only his father's indomitable courage, but his "waspishness," and, during the memorable siege of Jerusalem, A.D. 70, the father, discovering his daughter to be really in love with one of his enemies, sent for him, and gave his daughter a present—not as a token of his approval of the match, but of his views of what all beauty consisted in,—and it was the young Jew's skin!

Forgive me for here repeating a reference to the prophecy of what should follow the disobedience of the Hebrews, as made by Moses before the people entered Canaan: "The Lord shall bring a nation against thee from far, from the end of the earth, as swift as the eagle flieth; a nation whose tongue thou shalt not understand; a nation of fierce countenance, which shall not regard the person of the old, nor show favour to the young" (Deut. xxviii. 49, 50). And then think how literally this was fulfilled in this story of Titus, one of many which is bitterly remembered by every religious Jew in the synagogue, even to this day—that is, about 3400 years after the prophecy was made, and 1800 after it was literally fulfilled—when the "black fast," commemorative of their beloved city's ruin, is celebrated.

Look at the hornet's sting,—what a sharp two-edged sword it is! With this sword it will cut open the body of the honey-bee when it gets into the hive in search of honey, and, if the bees do not take to flight, suck all the sweets out of their bodies. And with such a sword did the Roman soldiers cut open the bodies of the Jews in the sacking of the city, when Titus dug his famous trench around it, as the carcase lay exposed to the figurative "eagles," who surrounded the coveted land of Canaan. For what purpose, do you ask, were these sharp swords

thus so cruelly used? For the extraction of the small golden coins, which, in their love of money, the captives had swallowed, to secure their safety.

Look at the hornet's tongue, and learn a lesson while comparing it with that of the bee. How different its structure! how different the lives of the two insects, though of the same family! How like to human life; what singular difference may be observed in different members of the same household! How active, busy, and thrifty one! how sweet the temper of another! but, alas, how waspish a third!

Here is a wasp-fly, so called from its striking outward resemblance to that insect. Look at *its* remarkable tongue, exceeding in beauty even the tongue of the house-fly. Now observe those sharp lancets with which the female deposits her eggs, after the manner of an ichneumon, in the bodies of its prey. Its number of lenses in its eyes, too! Only think of these all being *acquired* by a grub, which, in one family of the forty genera and upwards to which this creature belongs, the *Syrphidæ*, lives in a state of water and mud while in the first stage of its threefold life, it is provided with a long slender tail, through the extremity of which it respires, something like the larva of the gnat.

The family to which this insect belongs, like many parasitical creatures has for its life-work the destruction of other tribes of insects. And I was much amused and instructed, in a recent visit to a scientific friend in Gloucestershire, while watching the habits of another group, the wood-wasps in his garden.

Wishing to afford every accommodation to these insects who fed upon the caterpillars which destroyed his plants, and observing their liking for open crevices in the bark of trees, or any quiet corner where they might construct

a home for their children, he cut down the stems of hemlock, growing in the field, which, being hollow, afforded a snug place for the deposition of the wasp's eggs. Reducing these stems into lengths of about a foot each, he then made a small entrance, stopping up the two ends. His friends were thus anticipated in their wants, and were spared the trouble of building for themselves. Now, you must know that, amongst the solitary or wood genera to which the wasp belongs, some have a fancy for one class of animal food and some another. The whole species frequent flowers and woods, and they are appointed to keep down the excess of other insects; and, in the case mentioned in my friend's garden, were some curious illustrations of the marvellous instinct employed in their work, and the provision they make for their offspring.

Cutting open one of these stems of hemlock vertically, a curious scene presented itself. From top to bottom were a number of compartments, very neatly and cleverly contrived, each for accommodating the grub that would come from the parental egg. But each of these grubs would require food as well as lodging, and it was certainly very striking to observe how all these ends—namely, the destruction of destructive insects, the fashioning of a dwelling for a future group, which the fond parent, who fed, not upon animal, but vegetable life, herself sucking with that exquisite tongue the sweet matter found in flowers, would never behold—were accomplished.

Feeding upon my friend's plants were a number of very small, newly born, pea-green caterpillars, the larvæ of some lepidopterous species. Seizing one of these caterpillars, the wasp, with her sharp ovipositor, dropped into its body, through the minute opening, one egg; then, grasping the prey with her feet, away she flew to her hemlock home, and deposited that living caterpillar in one of the

chambers of its dwelling. And one after another of these unlucky caterpillars became the victim, until at last we counted sixteen living caterpillars in two cells, one containing ten and the other six. When the eggs so deposited became hatched, the inner grub would feed upon the outer, until the whole were destroyed, when the perfect wasp would emerge from the intermediate state—the pupa, that is—and escape through the open door.

My friend, whose eyes are always open for such interesting facts as these, gave me a description of how one of the ichneumon flies managed recently to obtain possession of one of those curious insects which, in the caterpillar state, constructs its dwelling by rolling a leaf around itself, in which to hide from its enemies. The ichneumon, making the best use of its many thousands of eyes, espied the caterpillar carefully concealed in its leafy bed, while attempting to enter; the other, frightened, endeavoured to escape at the back entrance, which the enemy, anticipating, instantly discovered, securing its prey, when the fatal egg was deposited in the victim's body to hatch in due time.

How many books have been written upon instinct! In what respect is it like intelligence? how often is the former superior to the latter! For some time this troubled me, knowing that many insects seem far wiser than myself; and I wondered whether this remarkable instinct, which is mysteriously associated with mind, would die out when its possessor was done with, until I knew that to the intellect of man there is added a spiritual nature, which is included in the passage with which we are familiar, "And God breathed into man's nostrils the breath of *lives*, and man became a living soul." *

* Gen. ii. 7. The Hebrew for *life*, when applied to man, is, in the Bible, always in the plural.

Are you tired with our work? Shall we change the subject, and pass from our examination of the very large family included in Insecta to what is so very intimately connected with it—the examination of some of the equally interesting works of God as seen in the stems, leaves, and flowers of our woods and gardens?

The relation of insects to plants is one of the most interesting chapters in the study of nature. We owe many variations of flowers and plants, doubtless, to the large tribes of insects who, carrying the pollen grains from one plant to another, produce that charming variety which so beautifully characterizes the vegetable kingdom.

These visits of insects are chiefly for feeding upon the honey which is found therein, for the extraction of which we have already seen so remarkable a provision is made, in the proboscis or sucking pump. The sweet scent and bright colours are another source of attraction, and "the lines and circles on the corolla guide them to the right spot." *

Not only for the purpose of producing a variety of changes in the same *species* of plants,—not in the *genus*, remember: no one but the Creator could do *that*, any more in plants than in animals; no heartsease, for example, by the instrumentality of an insect, could *acquire* the stature and property of a sunflower, nor by the visit of a humble-bee would the red clover become anything else but clover, though without such visit it would be "nothing but leaves;"—not only, I say, are insects useful to plants in the formation of their variety, as in that wonderful family, orchidaceæ, but they are sometimes busily employed in defending the plant upon which they live from the depredations of other insects.

* Lubbock.

Sir John Lubbock mentions an instance: "Thus a species of acacia, if unprotected, is apt to be stripped of its leaves, not directly for food but to grow mushrooms on. The acacia, however, bears hollow thorns, and each leaflet produces honey in a crater-formed gland at the base, and a small, sweet, pear-shaped body at the tip. In consequence, it is inhabited by myriads of a small ant which nests in the hollow thorns, and thus finds meat, drink, and lodging all provided for. These ants are continually roaming over the plant, and constitute a most efficient body-guard, not only driving off the leaf-cutting ants, but even rendering the leaves less liable to be eaten by herbivorous mammalia."

In a similar manner, while the ear-*wig* (which, by the way, should be ear-*wing*, from the striking resemblance the inner wing of this insect bears to the outside—the auditory chamber—of the human ear) is often busy seeking to devour the aphis which feeds upon the sweet nectar found upon our garden plants, the ant protects the aphis, proclaiming war against the ear-wig; and, in return, the aphis allows its friend, the ant, to suck the sweet juice out of its body which it has first taken from the plant. This kindness is again returned by the ants taking the aphis into its nest, and providing for it there in the winter season. And thus we may see, if we will but use our eyes, that this principle of giving and taking is to be found running throughout every department of nature, whilst the higher and grander principle of vicarious suffering—that is of substitution, or, one thing dying in order that another may live—runs through the whole world from a caterpillar to the highest type of mankind.

This deeply interesting subject would well repay you to follow by consulting a deeply interesting little book,

profusely illustrated, by Sir John Lubbock, on "British Wild Flowers considered in relation to Insects." In it, referring to my friend the honey-bee, whose self-told story may be read in "the Autobiography of an Acorn,* he says, "To them—that is the bees—we owe the beauty of our gardens and the sweetness of our fields. To them flowers are indebted for their scent and colour; nay, for their very existence. Not only have the present shape and outlines, the brilliant colours, the sweet scent, and the honey of flowers been gradually developed through the unconscious (?) selection exercised by insects; but the very arrangement of the colours, the circular bands and radiating lines, the form, size and position of the petals, are all arranged with reference to insects, and in such a manner as to insure the grand object which these visits are destined to effect."

Nor do these remarks in the least help the hypothesis of evolution, in my humble opinion. The variety and beauty to which the author of the book refers are simply and solely caused, not by any artistic or creative act on the part of the visiting fly, but by the interchange of pollen from one species to another, thus improving but never exchanging or advancing one plant to the genus of another plant. Our well-known author would appear to confirm this in his saying, "Every one who has watched flowers and has observed how assiduously they are visited by insects, will admit that these insects must often deposit on the stigma pollen brought from other plants, generally those of the same species; for it is a remarkable fact that in most cases bees confine themselves in each journey to a single species of plant;" and, in examining our prepared specimens of honey-bees for microscopical examination, in their stomachs you

* Sunday School Union.

will observe the pollen grains consist of one species of flower only.

Our field flowers, we have thus been told, owe their variety and beauty to the constant visits of insects; in one instance no less than 118 different insects have been counted visiting one flower; in another wild flower, out of every hundred insects visiting it no less than 58 were bees and 27 butterflies or moths.

You will understand more about plants when we look into our botanical collection of specimens, all, you will see, are carefully assorted according to their various structures, and from their minuteness fully justifying our title of inhabitants of the invisible world, being truly beyond our mortal vision without the aid of the microscope. But, ere we enter upon this very large field, and before we depart from our chapter on insects, which might have occupied us for many a long evening, for their name is legion, we cannot omit calling your attention to one which is well known, and erroneously considered as belonging to the same family as bees and butterflies in the great and important insect family, namely the spider. But because I shall have much to say to you, and some profitable "lessons" to suggest, as we journey together over Spider-land, it will be better to devote an entire chapter to this interesting subject: so, "lend me your ear," as Shakespeare says, while I unfold to you a few of the mysteries of some of the family which boasts the grand title of "Arachnida."

Comparison of Eggs of Insects with Seeds of Plants" (see p. 44).

This admirable cut was drawn from nature expressly for this work, by Mr. W. J. Norman, and the following is his description of the group of figures upon it:—

Seeds, represented in the four corners; A. *Nemesia versicolor*, a species of snap-dragon; B. *Lynaria cymbalaria*, or the ivy-leaved toad-flax; C. an umbellifer, allied to caraway seed; D. Petunia.

Eggs of Butterflies, etc.

1. The Red Admiral.
2. Cabbage (large white, B.)
3. Wood Fritillary.
4. Brimstone Butterfly.
5. Meadow brown Butterfly.
6. Large heath Butterfly.
7. Copper Butterfly.
8-9. House-fly (front and side view).
10. Tree bug.
11. Bed bug.
12. Sedge bug.
13. Parasite of pheasant.
14. Parasite of peacock.
15. Parasite of ground hornbill.
16. Parasite of mallee-bird.
17. Parasite of a duck.
18. Egg of the Boat-fly.
19. Ditto the Belle moth.
20. Veneer moth.
21. Clematis Emerald moth.
22. Cabbage moth.
23. Canary shouldered Thorn moth (front and side view).
24. Swallow-tail butterfly.
25. Yellow Shell moth.
26. Waved umber ditto.
27. Pink Bar ditto.
28. Flea of man (pulex).

Different Forms of Butterflies' Tongues (see p. 65).

Fig. 1. Head of Large White Butterfly magnified about eight diameters.

Fig. 2. Proboscis of the same, magnified about 25 diameters.

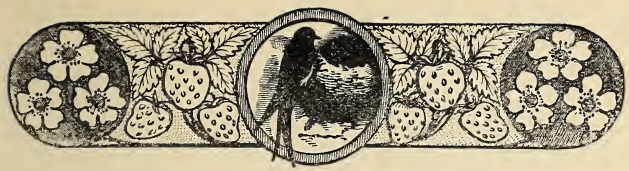
Fig. 3. A portion of the centre of same, about 100 diameters.

Fig. 4. Extreme end of same, about 100 diameters.

Fig. 5. Extreme end of the proboscis of the Small Tortoiseshell Butterfly, about 100 diameters.

Fig. 6. One of the lobes of the same, about 150 diameters.

All drawn from nature.



CHAPTER IV.

LIFE AMONGST THE SPIDERS.

"If thou intendest to vanquish the greatest, the most abominable, and wickedest enemy, who is able to do thee mischief, both in body and soul, and against whom thou preparest all sorts of weapons, but cannot overcome, then know that there is a sweet and loving physical herb to serve thee, named *Patientia*."—LUTHER.

WHAT is our lesson here—patience and perseverance. See, here is a fine specimen of the garden spider awaiting both *your* patience and perseverance in a careful examination of its curious body. It is nicely laid out on the glass slip, and first examining it with a low magnifying power and then gradually increasing the power, which we must always do in our microscopical studies,—for, remember, it is alike true in nature as it is in faith: the more we magnify, the more we see; and the more we believe, the more is revealed to our spiritual eyes;—we shall be astonished at the wisdom displayed in the life of a spider.

I told you that it was in my belief an error to include spiders in the great family of insects. The spider is not an insect: that word comes from the Latin *insecta*, to divide; and the spider's body is not so divided as are the bodies of true insects.

Spiders belong to a group which includes three divisions—scorpions, various mites, and spiders proper; and these are all included in the generic name "Arachnida;" so, if you wish to remember this, you may put them together thus:—

> The cheesemite, scorpion, and the spider
> Do form the tribe of Arachnida.

I suppose there is some relation between this very aristocratic denomination and the legend told us in Grecian mythology of the goddess Minerva, by whom the distaff—the ancient spinning machine—was said to have been invented, to which the Latin poet Virgil refers thus:—

> "To Pallas' arts her hands were never trained,
> By th' spinster's trade she gets her livelihood."

The spider, like Minerva, lives to spin and spins to live; but, unlike Minerva, the true Arachne is a reality, while the Grecian goddess was an imposition.

You must know, then, that, according to the pagan story, although Minerva so much excelled all others in spinning, yet Arachne, a young lady of Lydia, very skilful at spinning, challenged her in this art: but it proved her ruin; for the goddess tore her work and struck her forehead with one of the spokes of her wheel. This disgrace drove poor Arachne into despair, so that she hanged herself; but Pallas, which is another name for Minerva, out of compassion, brought her again to life, and turned her into a spider, which still continues its spinning. You will allow this story to be *really* a *beautiful myth*, but yet how unlike our Bible stories!

Should you be inclined to listen to a further bit of gossip, while we look at our spider, let me tell you the origin of our English word "spinster;" it signifies, you know, an unmarried woman.

Our Anglo-Saxon forefathers in summer brought home the fleece to be spun into woollen cloth during the winter, and the daughters of our Saxon kings and princes were so employed long before the Norman conquest. Alfred the Great, in his will, calls the female part of his family the *spindle side;* and it was a regularly received axiom with our frugal ancestors, that no young woman was fit to be a wife till she had spun for herself a set of body, table, and bed linen. Hence the maiden was termed a "spinner," or "spinster," and the married woman a "wife" (from the Saxon "*wif*," to *weave*), that is, one who *had been* a spinner.* How many lessons have others before us learned from spiders! You remember that passage in the poem of Job —the oldest perhaps in the world: "Ask now the beasts and they shall teach thee,"—wisdom, that is. Robert Bruce, the brave Scotch king, did this in his extremity; for, failing in his opposition to the King of England, it is said that he owed a final victory to a spider, which, failing just as many times as he had done in its endeavour to reach its object, made one effort more and succeeded; and from this incident in Bruce's history no one in Scotland of the name of Bruce will ever kill a spider. The motto of a spider is that which you and I would do well to take for the motto of our lives in everything we do: "If at first you don't succeed, try again." "*Preliminary failure is often necessary to ultimate success.*" These words were spoken to me many years ago, and ever since I have made it the business of my life to love a difficulty for the sake of conquering it, finding that, with too many, boasted strength is nothing but undeveloped weakness.

Now, then, for a sketch of some few of our spiders; for I believe there are upwards of three hundred species in Britain.

* From "The Dictionary of Phrase and Fable," by Dr. Brewer.

Remember, a spider is not an insect: first, it is utterly destitute of wings; secondly, it never undergoes any transformation; thirdly, the head is not separated from the thorax as those of insects are, but is united to it, there being only two great divisions of the whole body, instead of three; fourthly, the eyes, which are generally eight, are of a totally different character to those of insects, which are often compound. In the dragon-fly, for example, we are told by a competent author,* there are no less than 36,000 separate lenses, measuring a little more than only a thousandth part of an inch in diameter, each being really a separate and distinct organ, with its own crystalline lens in front and microscopic telescope behind, running back to the retina. But, having given a pictorial description of this in another place, I need not do more here than remind you of the difference of structure and number between a spider's simple eye and that of an insect; perhaps, as we get further on in our story, we may come across the truly wonderful eyes of some spiders, which will astonish you by the perfection of their workmanship, and you will exclaim something more pleasing than did a very raw countrymen to one, to whom I am indebted for many interesting facts in natural history, who, while exhibiting parts of insects, just as I am now supposed to be doing to you, heard him exclaim, "*Lor, don't they get 'em fine in Lunnon, eh?*"

How very different to the exclamation of a poor African slave-boy, who, falling into the hands of our sailors a few months ago while our war-ships, acting in conjunction with Germany, were off the coast of Zanzibar, when rescued and received on board one of our big steamers, as he was led from one part to another, was

* Henry Walker, F.G.S., in the *Leisure Hour*, April, 1886.

heard to exclaim, "This could not have been made, it must have been created!"

There is a fifth reason why the spider should not be classed with insects: it has eight legs, while ordinary insects have six. The nervous system, too, is far removed from that of insects, as I will show.

That spiders have existed on the earth from a very remote period, is evident from the fact that various fossil specimens have been found in the coal formation of Shropshire. The nervous system is their distinguishing characteristic. In man the seat of sensation is in the brain, and consists, as we shall see when we come to our anatomical study, of a number of convolutions, each of which, says the phrenologist, has its own particular function to perform in the phenomena of our lives. What we call *brain* in man consists, in insects, of a series of knotted nerves called *ganglia*, which extend to every part of the body. Insects generally have from six to ten of these little brains, or ganglia, diffused through their entire forms; spiders have only two, but they are more like the true brain with which we are familiar, as being more concentrated: consequently, spiders are of a higher order, and we shall see what good use they make of their two brains, as we may with our double lobe if we will.

Another very striking difference between insects and spiders is to be seen in the circulation of that life-giving fluid we call blood. In man the pumping-machine for this vital fluid is the heart, which involuntarily beats against our ribs day and night as long as we live, at each stroke reminding us of our mortality. Spiders are provided with a true heart, unlike insects, and this heart is furnished with arteries and veins, giving it, as in the higher animals, perfect circulation.

Then, again, spiders breathe in a manner more resembling higher animals than insects, intricate and singularly characteristic of creative wisdom as they are. Though a few of them breathe by tracheæ, the majority do so by pulmonary sacs.

Now, after this long preamble, let us take a peep down our magic tube, and see what there is to be seen with our own eyes.

Head of a spider.

"*Eyes.*" Look here! How they stare at you! How I pity a poor fly directly the spider "eyes" it! Each of these eyes look, for all the world, like the bull's-eye lens of a policeman's lantern, with the dazzling light glaring through the glass covering.

That good man, and able naturalist, whom we have recently lost, Philip Gosse, thus describes the mechanism and occupation of spiders: "The whole tribe," he says, "is sent into the world to perform one business—they are commissioned to keep down what would otherwise be a 'plague of flies.' They are fly-butchers by profession; and just as our beef and mutton butchers have their slaughter-house, their steel, their knives, their pole-axe, their hooks, so are these little slaughterers furnished with nets and traps, with caves, with fangs and hooks and poison-bags, ready for their constant work."

Our specimen is taken from the great garden spider. Its eight eyes are placed on the top of its head in such a position that, as the Irishman's gun was so fashioned that it would "shoot round the corner," so they can see in every direction. The four middle ones form nearly a square, and the two on each side have the power of survey which

brings the image in contact with the rest. It is not a little remarkable that the disposition of spiders' eyes is exactly proportioned to their several habits; so that in no sense have they been *acquired* according to the theory of evolution.

Now fancy I am showing you the eyes of the large jumping spider, scientifically known as *Salticus tardigradus*, retaining their natural form and brilliant colour. You see they are prepared without pressure, in glycerine, and give you all the appearance of life, being mounted in a deep cell, which contains the whole head of the spider. Did you ever see such eyes! Why, they shine like so many globes of pure opal! Observe the combination of optic mechanism for the perfection of vision, the arched cornea and spherical lens, its concave-convex body, and cup-shaped retina, with its layer of pigment. "How wonderful!" you say. Truly so. These shining hemispheres, we are told, are, in each case, covered with a thick cornea, a continuation of the skin, which is perfectly transparent, and thrown off in the process of moulting; for I must tell you that as spiders increase in bulk their outer garments do not increase with their inner growth, and they throw them off as exuviæ. I shall show you presently one of these cast-off coverings, exhibiting the entire outside form of the spider just before it would have appeared in its new dress. But to think of these beautiful eyes! Let us take one more striking than the rest, and, following the admirable description of a reliable author,* very carefully observe the wisdom of God displayed in this act of creation.

The centre of its inner surface is deeply excavated for the reception of a crystalline lens, which, you will observe, is globular in form, and which rests behind on

* The late P. H. Gosse, F.R.S.

the front surface of a hemispherical vitreous body, without sinking into it. The space between this body and the sides of the lens forms a ring-like channel which is filled with an aqueous humour, and into this projects a circular process of the thick pigment-coat, which corresponds to the choroid, thus defining the pupil of the eye, and at the same time confining the lens to its proper situation. The margin of this pigment-ring may be considered as an iris, and is of various colours, as red, green, or brown, which are active by daylight, while, at the back of the eye, it is black.

Now *do* just reflect again at the important lesson taught us here. Those spiders which hunt in the light of day have their eyes fashioned according to their necessities, while those who hunt at night have an altogether different adaptation to their varying instincts. Does not this suggest to us something beyond an "acquirement"? The black pigment found in day-hunting spiders does for the spider what the *pigmentum nigrum* (black pigment) in your eye and mine does for us; that is, exactly what the black pigment in the camera of the photographer does for him—suggestive of the idea that the eye acts like a photographic camera,—namely, absorbs the superfluous pencils of light after they have made their impression of the outer object brought to the "sensitized" surface both of the eye and the camera; but were the same structure observed in the eyes of such spiders as usually hunt at night, that is in the dark, where would *they* be? So, what do we see in night-hunting spiders' eyes? Why, a luminous curtain reflecting a bright metallic lustre, making them glare in the darkness like those of cats, whose eyes they resemble.

Surely here is clear evidence of creative wisdom, and not merely of a "fortuitous concourse of atoms." What

greater evidence could be afforded of the wisdom of God! what greater proof of design! How much do we owe to the invention of an instrument which so clearly and unanswerably demonstrates the existence of the Deity and His care for all His creatures!

Now you will learn why spiders are not classed with insects. Among other reasons, their eyes are not only entirely different in their structure, but altogether different in their number.

Following the various parts of the body of our object, look at its mouth. Did you ever see such a tremendous weapon? Observe, first the size of these so-called "mandibles" (from the Latin, meaning "a jaw"). They close, when striking the prey, like the blades of a clasp-knife. Their minute points, where they terminate, are hollow; and, through a very minute aperture at their extremity, a poisonous fluid is ejected into the wound made by the sharp point, from a little sac in the upper joint, where the intense poison is kept, the injection of which immediately so stupefies the victim that it probably ceases to feel while it is being despatched. Just think now: from the same raw material, namely, dead flies or other insects, the spider contrives to manufacture in that big workshop of hers—first, food for the preservation of life, and the increase of growth and strength; then, secondly, a preparation of the most subtle and fatal of poisons; and, most wonderful of all, that curious web, which we shall presently look at and cry out, saying, "My word!"

"My word" indeed! But what does "*My Word*" say about spiders? for does not it say something about everything? What does "My Word" say about a spider?

"Bide a wee, and do not weary," was a little Scotch child's definition of *faith:* let it be ours of *works.* We shall see presently.

Now for a peep into another part of the invisible world which should not only astonish but delight you. "My Word" says something about a spider's hands.* Just "put on your thinking-cap," as some say when they are about to exercise their brains in a weighty matter,—*think*. The garden spider has to make a geometric web upon which it means to catch flies. It is, perhaps, one of the most curious of all habitations, and vastly different to the bee's, though equally illustrative of design: but how *can* there be design without a designer?

When I made a large diagram for my lecture upon the garden spider, I had to employ the compass with which to draw a circle. How did the spider "acquire" her knowledge of that? Then, secondly, a spider's net surely is not the easiest of all floors to walk over, for, slipping through the absolutely countless divisions, the poor creature would soon come to grief on the earth below, and become food for the birds. Some kind of contrivance, therefore, must be necessary to prevent this for the foot which has very hurriedly to run over the web in order to secure food.

Again, the garden spiders, called the geometric spiders, make their lines equidistant. With what tool can they do this? Where there is contrivance, there must have been a contriver. What has been contrived for the spider's foot, and who contrived it? Has it, after all, been simply *acquired?* Never! Then, again, the web, as we shall very presently see, is a much more complicated affair than is generally supposed. It is covered with viscid globes, made by the spider, upon which some smaller insects—many far too small for your eyes and mine to see without our microscope—are secured. In dusty or windy weather these globes are liable to be damaged, or

* Prov. xxx. 28.

covered with dirt and dust, or altogether destroyed by wind. Would not some suitable instrument be good with which the creature should be enabled to clean its curious house?

Now, please, behold the garden spider's foot. "Why," you exclaim, "it's a comb, and what a number of hooks and spears are attached to it!" True, quite true; but let us think a bit while we examine with a higher power this most astonishing display of wisdom.

Here is a foot exactly in the form of a comb. The teeth resemble exactly the fingers of your hand, and are used precisely in the same manner; and you did well to exclaim just now "My word!"—an exclamation expressive of astonishment; for "My Word" says, "The spider taketh hold with her hands, and is in king's palaces,"*—teaching us, by a natural parable, that if we are to dwell in the King's palace of heaven we must first take hold of the way He has provided for us on earth.†

These combs number about twenty teeth each, and, though they are quite invisible to the eye, the microscope reveals them so distinctly that you may easily count them. Then, as it is wise to have a duplicate instrument when the first is likely to suffer damage, observe there are two combs to each of the eight feet. I can only suppose these duplicate combs have been wisely given to the spider for the purpose of supplying that loss which these animals often sustain in their battles one with another, for spiders are terribly pugnacious. Observe, these teeth are so evenly and so closely placed that just room enough between each allows one strand of web to lie, so the spider has secure footing in its curious house, and cannot fall between the meshes of its net. Then, again, this admirably contrived foot is a perfect gauge

* Prov. xxx. 28. † Matt. xi. 29; John xiv. 6.

with which its geometric web is measured, and so, thus, it is a *foot* to walk with, a *comb* to clean, and a *gauge* to measure.

Now, while endeavouring to learn a lesson from what naturally belongs to the invisible world, let me show the foot of another spider, that you may compare it with that of the *garden* spider.

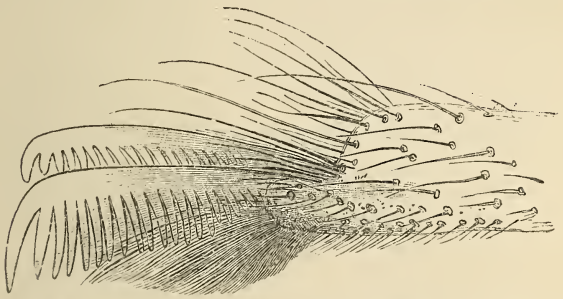
Spiders, just like many men, have their own reasons for dwelling, not only apart, but in different spheres and different localities. Some prefer to float in the air, like a balloon; others are fond of the water, and live in a most wonderful air-proof house in the midst of what you would say must drown it. Some prefer our company in our houses; others the fields; many we know of in our gardens; and one branch of this very much abused family has a peculiar fondness for the cellar. The extraordinary large webs to be found in some cellars almost suggest combined effort.

Here is the leg and foot of a cellar spider, which has astonished and delighted many a beholder. May you be reckoned among the number!

Now, an animal that lives in a coal-cellar is subject to be in a constant state of dirt; and because the spider who thus lives must subsist only upon what it catches there, and because it has one way only of catching flies, upon which alone, like its numerous relations, it can feed, it needs especial instruments, not only to keep its body but its habitation clean; for if it have no web it can have no fly, and without a fly it can have no web. What do you say? "Why, here are not only combs, but brushes too!" Just so; and "not only combs," as a dear old lady once exclaimed when I showed her this deeply interesting specimen, "but *tortoise-shell* combs also,"—in allusion to their transparent colour, which you see is a reddish

brown. But what about the brushes? There they are, all neatly arranged behind the combs, thus providing a necessary apparatus in so disagreeable an abode as a coal-cellar.

Now, just conceive a man going into a hairdresser's shop. His object is to have his hair cut, and perhaps, if it be a hot day, "shampoo'd." The attendant puts a circular brush into the band of a machine, which, by a mechanical contrivance invisible to the visitor, is worked by human machinery overhead; he may never have seen this novel contrivance before, and is perhaps struck with



Brush and combs of a cellar spider. Drawn from nature.

its admirable application, and asks, very politely, to be informed who was the inventor.

"Inventor!" replies the attendant; "it was never *invented:* "we *ac*quired it, simply because we *re*quired it."

Would it be *very* naughty for our inquiring friend to say to himself, "What a fool!"?

I was once invited to interest a large company of working men and women at a big tea-meeting. I was begged to take my microscope and a few interesting objects, and the vicar of the parish asked me to address the company, which consisted of from four to five hundred. I thought the best address I could make would be a short

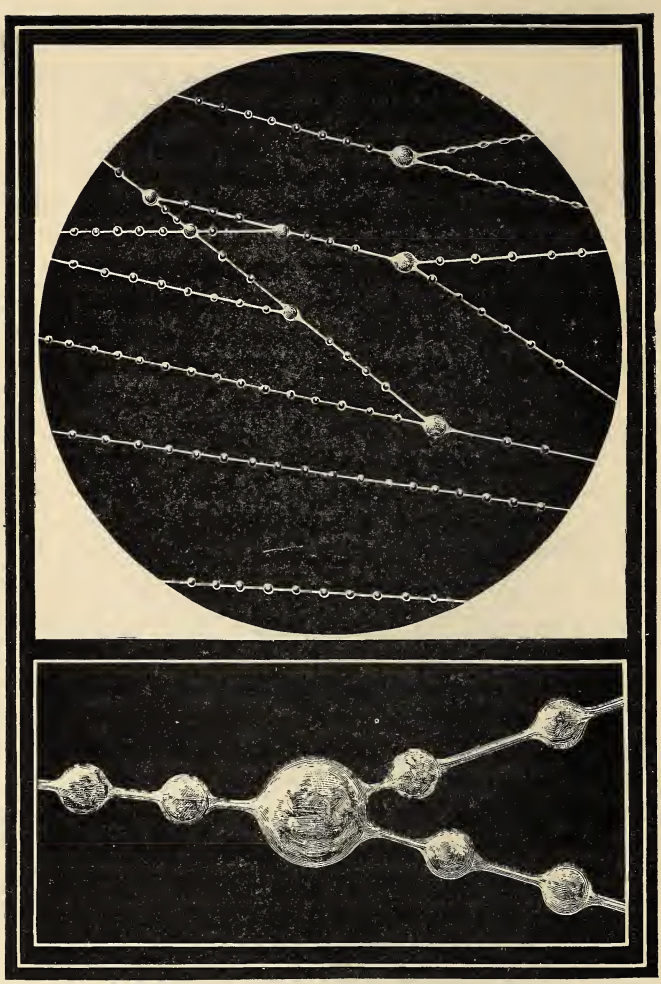
description of the objects I had brought to exhibit; so, after a few words, I began the exhibition with the foot of this spider, and so intensely interested were these people, and so completely "flabbergasted,"—to repeat my friend's exclamation,—that beyond this object I could not get; it afforded matter for new thought to all who saw it. Will it do so to the reader, I wonder?

Now, after this story, let us proceed to examine the spider's web. This is mounted so that we may see it both as a transparent and opaque object. The latter is preferable, so we use our bull's-eye lens and see it by transmitted light. "Why," said my precious wife, the first time she saw it, "it looks just like golden beads on silver strings,"—alluding to the viscid globes suspended on the lines of web. Now you will understand why the combs are necessary to keep these exquisitely delicate threads from encumbrance. Verily, I know not where to begin when I attempt to express my thoughts about the spider's web. Our poet Pope says, in reference to the creature's fine sensitiveness of *touch*,—

> "The spider's web, how exquisitely fine,
> Feels at each thread, and lives along the line."

And Shakespeare, in reference to the healing property of spiders'-web—that is, the weaver spider, for while some are spinners, others are weavers and rope-makers,—says, "Good Master Cobweb, if I cut my finger I will make bold with thee." Another of our own poets, Dryden, is less gentle in his dealings with our friend, and writes—

> "The treacherous spider, when her nets are spread,
> Deep ambushed in her silent den does lie,
> And feels far off the trembling of her thread,
> Whose filmy cord should bind the struggling fly;
> She issues forth and runs along her loom,
> Eager to seize the captive in her net,
> And drag the little wretch in triumph home."



Part of garden spider's web, drawn from nature; the lower portion an enlargement of one portion of the upper figure.

Among all the uses to which the spider's web has been applied, I know of none more striking in the contrasts of nature than that seen in the fact that in the "finder"—the small tube attached to the best of telescopes—there are divisions made, a cross appearing in the circle, thus cutting it into four equal parts, so that such a mighty sun as Sirius, that is said to be more than 13 billions of miles from us, shall be fixed by the finder for the bigger instrument,—that these divisions are obtained from the thin, fine web of the garden spider, that being said to be the finest line that can be formed, and so used by the astronomer for the observation of worlds in the sky, many thousands of times larger than the earth, and at a distance beyond all human comprehension.

Here is an exact copy by a clever artist of this very object, exactly as it appears to you. Observe, these viscid globes have the thin line running through them; then note, in one or more instances, the thread passes down and through, and then takes a contrary direction, passing up to join another line: it is actually a pulley, and can be so employed when the net has been slackened by weakness.

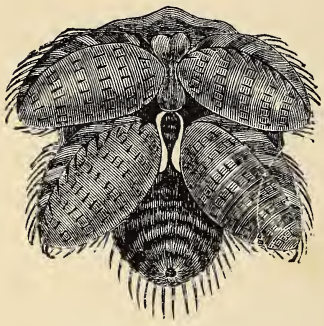
A large common garden spider will begin and finish a net of fourteen or sixteen inches in diameter in about three quarters of an hour, which contains 120,000 of these viscid drops.* How are all these thousands of "golden beads" made—that is the question?

When the lines are first thrown out of the spinnerets, they have been found to be free from them; after a short time undulations have appeared along the filmy lines, and, subsequently, at the most regular distance, the viscid matter becomes formed into alternating large and small globules by a process of molecular attraction.†

* P. H. Gosse, quoting Mr. Blackwall.

† The late Richard Beck.

The next part of our object to which I must direct your attention is the said spinneret. At the end of the rounded body you will see four or five teat-like protuberances, and, if we increase our magnifying power, we shall perceive a number of very minute apertures in each. The total number of these spinning-tubes varies greatly, according to the species of the spider, and the sex and age of the individual, being more than a thousand in some cases and less than a hundred in others.* It is through these microscopical orifices that the persevering creature throws out the hundreds or thousands of liquid lines which, with its wonderful "hand," it twists into that one minute strand, just as the little fibrous bit of flax is made into the bit of string, so that each fine thread that you see in the beautiful net of a garden spider really consists of thousands of threadlets of fluid made in that big workshop of its stomach, which, when united by the workman, become comparatively a cable, both in strength and structure.



Spinneret of a spider.

But, observe, the net of such a spider as we are now looking at consists of two different kinds of thread, though each thread is formed from the same raw material. Were our specimen uncovered, and the lines fresh from the air, you might put your finger upon those which radiate from the centre to the circumference, and they would not adhere to it; but were you to do the same with the long spiral line which is supported upon that delicate frame-

* Dr. Carpenter.

work, then you would find the viscid globules, which stud the whole of that wonderful circle, would stick to the finger.

When a spider wishes to pass from one side of a locality to another, where there is danger, as, for example, a country lane or a garden path, it makes a bridge of these threadlets, upon which it may safely trust itself, taking care to pull the cord with its "hand" before trusting itself upon it, to ascertain whether it has adhered to the opposite side; then, venturing, it takes good care to make another bridge, so that, in the event of one failing, it may beat a retreat back to its home by the other.

Amongst all the lessons we may learn from this inhabitant of the invisible world—partially invisible, that is, in the work it does and the tools it employs, without the aid of the microscope,—I know of none greater or more worthy of our imitation than the lesson of economy which it employs. When the net is complete, the radiating lines, which are the rafters of the building, after adherence to some outside object, have their fag-ends hanging from their extremities. Commencing the long spiral line, she walks quietly round the outer path, and, carefully cutting off the loose pieces, swallows them like so many boluses, making fresh material for renewed work. Here is a reminder of the Divine words, "Gather up the fragments that remain, that nothing be lost." Fragments! why, all our lives are made up of fragments!

"The moments fly, the minutes come;
The minutes fly, an hour is run;
An hour is fled, the day is here,—
Thus flies a week, a month, a year.

"A year, alas! how soon 'tis past
Who knows but this may be our last?
A few short years, how soon they're fled,
And we are numbered with the dead!"

Every time the clock ticks it speaks to us in a fragmentary second; the pendulum is solemnly vocal. "Now! now! now!" it says; and another voice silently joins in the sound—"Passing away."* "Economy"!—let me give you an illustration. One evening I was sitting in my study, very busy a-thinking. I saw a very minute spider descend from the ceiling, lowering itself by the rope it let loose out of its spinneret. That little creature was no bigger than a grain of sand. When it came within my reach I mischievously sent a whiff of tobacco-smoke over it. For a moment it seemed stupefied, but, directly recovering itself, it rushed upwards along its rope, *taking care, however, to haul it up after it;* and I have no doubt that, could I have seen what was going on aloft, it would have been found to swallow the rolled-up thread and have been immediately employed in its remanufacture.

How many lessons may we learn from this remarkable creature, which for centuries, nay! for ages, as we have said, has been silently preaching to our race! Will you think I am going a little too far in teaching you a lesson of heavenly-mindedness from such a humble thing as a spider? Let me try.

I told you that there are water-spiders—that is, those who have a fancy for building their dwellings in ponds and streams, where they may safely rear their young. You may have seen the human diver going down into the water, while from dry land a pump supplies him with air to enable him to carry on his dangerous work below: well, the aquatic spider is a diver, but the method *she* employs is far cleverer than that of the human diver; for, under those eight little legs of hers, she contrives to

* Motto over the large clock in the South Kensington Museum.

convey into her sub-aqueous nest, where she means to lay her eggs, little globules of air, which, as she passes from the upper world, shine in the water exactly like globules of quicksilver. "The shining appearance," says one,* "proceeds either from an inflated globule surrounding the abdomen, or from the space between the body and the water. The spider, when wishing to inhale the air, rises with its body still submerged, and only the part containing the spinneret just appearing at the surface, when it briskly opens it and moves its four teats. A deep cone of hair keeps the water from approaching or wetting the abdomen. It comes up for air about four times an hour or oftener." Another author, De Geer, tells us how "this species of Arachnida spins in the water a cell of strong, closely woven white silk, in the form of half the shell of a pigeon's egg, or like a diving-bell. This is sometimes left partly above water, but at others it is entirely submerged, and is always attached to the object near it by a great number of threads. It is closed all round, but has a large opening below, which, however, I found closed on the 15th of December, and the spider living quietly within, with her head downwards. I made a rent in this cell and expelled the air, upon which the spider came out; yet, though she appeared to have been laid up for three months in her winter quarters, she greedily seized upon an insect and sucked it."

"What has this to do with 'heavenly-mindedness'?" did you say? Let us see. These water-spiders gather the air around their bodies, and then descend into the stream, retaining still their aerial garment as their safe protection. So should the Christian be in the world: his spiritual life is derived from Him who is *the* life, and this spiritual

* Clerck, quoted by Rennie.

life, so derived, is intended as a protection from the destructive influence of the world, preserving around him who will receive it the atmosphere of heaven.

I have told you how the spider tests the strength of its rope before trusting its body upon it: another thought here affords a good text for a homely lesson; but how does it know that such extreme tenuity is sufficient to sustain its own weight?

To ascertain the strength of a rope, we more advanced animals, who once upon a time, some æons of ages ago, were "not human"* (!) multiply its circumference in inches by itself, and the fifth part of the product will express the number, say of tons, the rope will carry. For example, if the rope be six inches in circumference—$6 \times 6 = 36$—the fifth of which is $7\frac{1}{5}$; we thus ascertain a rope of six inches in circumference will sustain a weight of seven tons and a quarter. It were a curious calculation to ascertain whether this law applies to the finest home-made thread in the world, and whether the line placed in the elaborate scale of an analytical chemist, which will tell the weight of a human hair, would correspond relatively with the weight of the creature who made it.

To form some idea of the circumference of a spider's web, let me tell you that in some species, which are not larger than a grain of sand, so very finely drawn are the lines, that four millions have been reckoned as not exceeding the circumference of a human hair; and yet this extremely fine rope is a compound of so many smaller threads, that in the six spinnerets of one full-grown spider one thousand in each have been counted, from which the liquid matter has been thrown out for the purpose of making the curious net with which the clever workman

* According to some modern lights.

shall take his captive fly. These lines of web give us an idea of a telegraph-wire. Hiding in a hole very near her dwelling, the spider fastens one of the lines to her web, and attaches it to herself in her hiding-place, and directly the message comes for which she is waiting, she rushes down upon her victim just like a cat upon a mouse.

I have likened the spider's web to a telegraph-wire, believing it to answer a similar purpose, namely, the conveyance of news. While these pages were in manuscript, that is in the autumn of 1889, I visited the busy city of Antwerp, and crossing one of its thoroughfares by the side of the river, to my great delight I saw a novelty in the telegraph-wires, and this cut represents it.

Viscid thread, A, and ordinary thread, B, of garden spider. The former *exactly* represents the Antwerp telegraph-wire.

Now, where do you suppose I found this very figure? In the late Dr. Carpenter's work on "The Microscope and its Revelations," p. 685.

It is very interesting to see what pains the spider takes in ascertaining the completion of her work. When it is finished she pauses, surveys it, tugs hard at each thread, then shakes her body hard and plump to test it, breaking off with the thumb of her "hand" any loose parts, and actually replacing defective strands, and then running a number of small circles in the centre of the net closer to each other. Thereafter comes a storm or some rude hand and sweeps all away, and she has nearly emptied *herself* over that precious net. What will she do? Give up? Never! "Never give up!" is a spider's motto; why should it not be ours?

"*Never give up;* it is wiser and better
Always to hope than once to despair;
Fling off the load of doubt's heavy fetter
And break the dark spell of tyrannical care.

"*Never give up*, or the burden may sink you;
Providence kindly has mingled the cup:
And, in all trials and troubles, bethink you,
The watchword of life must be '*Never give up.*'

"*Never give up;* there are chances and changes
Helping the hopeful, a hundred to one;
And, through the chaos, High Wisdom arranges,
Certain success if you'll only hope on.

"*Never give up;* for the wisest is boldest,
Knowing that Providence mixes the cup;
And, of all maxims, the best, as the oldest,
Is the true watchword of—

'*NEVER GIVE UP!*'"

How many very striking instances of wisdom have been registered connected with such a very ordinary thing as a spider's web! Some years ago, one had built her beautiful nest just outside our sitting-room window, thus affording me a capital opportunity for observation. Presently a fine specimen of what is commonly known as "daddy-long-legs," or crane-fly—scientifically, *Tipula*—dashed into the snare, poor thing! I knew she had taken her last flight. Down rushed the spider, and the first thing it did was to bind its rope round the large wings so that escape would be impossible; and the next to bind the legs so that the net should not be broken. Then began the meal, and, in a very short time, nothing but the skeleton of the victim was to be seen—a warning to those who do not keep a distance from all who are watching whom they shall devour.

The following incident was witnessed by a correspondent of the *Times* newspaper, and communicated to

it some time ago. A boy removed a small spider to place it in the centre of a big spider's web which was hung among foliage, and distant some feet from the ground. The larger animal soon rushed from its hiding-place under a leaf to attack the intruder, who ran up one of the ascending lines by which the web was secured. The big insect gained rapidly upon its desired prey; but the smaller creature, when barely an inch in advance of its pursuer, cut the line behind itself, so that the bigger one fell to the ground, affording time and opportunity for an escape along the ascending rope of the web,—thus indicating that a spider's *instinct* may almost, if not quite, equal what we call *reason.*

One of my entomological friends, who knows how to make the best use of his eyes, once told me of a hunting spider, living in the earth, in a solitary cell, having no web like our garden spider, that was accustomed to weave a net over the door of its house when it went out searching for flies, so that its meal might be ready on its return in case its search had been in vain elsewhere.

That prince of entomologists, Kirby, tells us that one day he placed a spider on a tall stick set up in a vessel of water. It dropped from the top of the stick, not by a single but by two separate threads, distant only one-twelfth of an inch from each other, guided, as usual, by its hind feet. When it reached the water it stopped short, finding it was in danger of its life; then it broke off one of the threads close to the spinneret, which, still adhering to the top of the stick, floated in the air, and was so light as to be carried by the lightest breath: at length its glutinous nature caused its adherence to some distant object, which the creature discovering, climbed up the stick, tugged at the extended thread, and, when it had satisfied itself of its sufficiency of strength, it walked

down its self-made bridge in safety, strengthening it by another strand in case it might want to return.

A big volume might easily be written upon the wisdom displayed by this persevering creature, so much abused because it happens to have a reverse side to that which I have thus briefly described for your edification and imitation; but what living creature is there that has not two sides to its character? The nearer we aim at the bull's-eye of the target, the surer we may hope to reach the centre; but, alas! there are too many who go very wide of the mark simply from having taken what is called "*a bad aim.*"

"Cunning and fierce,
Mixture abhorred!"

writes Thomson, describing a spider's life rather harshly in his poem of "The Seasons." Here is one illustration of the poet's truth. When the honeymoon of Mr. and Mrs. Arachne is over, the husband has to make the best use of his eight eyes, or Mrs. Arachne will make short work of him by chawing him up to make cobweb; so he, fully aware that his short-lived happiness may meet with an untimely end, and knowing that the carnivorous propensity of his spouse declines *dead* animal matter, assumes all the characteristics of defunctation, and, rolling up his eight legs as in death, lies still, knowing, from the superior bulk as well as speed and strength of his wife, that escape is hopeless. Taking "a last long lingering look behind," she leaves him to his melancholy fate; but, directly she has disappeared, new vigour possesses the animated male, who shows us that his big brain, eight eyes, and as many feet were not given him in vain.

As a set-off to this cannibalism as exhibited by one sex toward another, let me tell you of the extreme love the spider has for her children. In no respect do spiders

show their wisdom more than in the building of their egg-bags, the material of which, though made from the same animal matter as the web, in the same loom, and with the same apparatus, is of a totally different description, the latter resembling cotton and the former silk. The egg-bag of the spider,—which, as we have already seen in the case of some garden spiders, may contain so many as 170 eggs—is a very clever contrivance, being made entirely of silk, and carefully concealed in some out-of-the-way corner in the garden. She knows perhaps that these children of hers will never be seen by their parent, and yet she has been taught to love herself last, so that they who will survive her may have sufficient food to last them till they are old enough to find it for themselves. Among all the quaint epitaphs which may be read upon some of our older tombstones, I know of none more so than one erected to the mother of twenty-one children, which runs thus :—

> "Some have children, some have none,—
> Here lies the mother of twenty-one."

Did the mother of that thrice-perfect number display the same maternal love that this spider would have done, whom you might have roasted alive, firmly clutching in its hands its baby-bag, choosing rather to perish than leave go its hold?

One lesson to be got in the study of spiders is to avoid their quarrelsome disposition. It was thought at one time that spiders' silk, if its production could be cultivated, might enter into competition with silkworms', and for this purpose breeding spiders upon a large scale was attempted; but in vain. The bad tempers of the family bred nothing but quarrels, which ended, as sometimes they have ended in the quarrels of another family

of animals, fatally. From the spinnerets of a spider the wheel of a toy steam-engine has drawn out 150 feet per minute, continued for from three to five minutes; and some years ago, from one spider 18,000 feet of silk were thus drawn, resembling spun glass, and measuring one-fifth less in diameter than that drawn from a silkworm. The quantity of silk equal to that drawn from a silkworm would require the work of more than six spiders; so that, as it takes 3500 silkworms to produce one pound of silk, nearly 23,000 spiders would be required to produce the same quantity. A pair of stockings is said to have been made from this silk,* and there was a report in the newspapers not long ago of a present of a dress from the Emperor of Brazil to our good Queen, made entirely from the silk of 17,000 Brazilian spiders. What a curiosity!

I have already said something about the spider's quarrelsome disposition, but I have not told you one very remarkable illustration of a spider's wisdom when it has paid the penalty thereof in the loss of a limb. When one leg has been bitten off in the struggle with an adversary, the damaged spider will quietly retire into seclusion, and, with the sharp jaws of its own mouth, separate the injured member from *the joint*, when it will grow again.

There are some good people who think that by self-denial they can cure the body of its evil propensities. Everybody knows what this too often leads to when the "fast" is ended. So is it with spiders. One kept under glass for ten months, without food, when released attacked another spider, and carried off limb after limb. During its imprisonment it had eaten three of its own limbs, each stump being properly removed at the joint, reappearing in the new growth.

* Kirby and Spence.

Said a good friend to me, "I cannot see what pleasure you *can* have in the study of such vermin as these. What *is* the use of spiders and worms?" I tried to explain to him the value of the earthworms, in that every bit of garden-mould has been produced by them, and that long before the creation of man worms were the humble instruments which God used in the preparation of the soil for the seed which man should be employed in sowing. "What's the good of spiders?" They preserve the balance of life; thus affording food for the birds; the nightingale finds both food and medicine in poor Arachne. A fine plump garden spider is said to be an effectual voice-lozenge for the sweetest of singers, while the merry and almost omnipresent sparrow finds in the spider the necessary and gentle purgative for the greedy nature of its appetite. It is computed that a pair of sparrows will destroy upwards of three thousand caterpillars in a week, and when they have thus indulged we may easily believe they *may* suffer from indigestion; but a few small spiders put them right in their over-indulgence of appetite, and a good fat one or two correct serious consequences, and produce convalescence.

In some parts of the world the natives are blessed with spiders about an inch in length, which they catch and eat after roasting. One young lady is reported as having such fondness for raw spiders that she put them into her mouth, cracking them like nuts, which she said they nearly resembled.* Not one whit worse was this than the fancy the Romans had for roasted caterpillars or grubs, spread, as we have butter, upon dry toast; but "there *is* no accounting for taste." Shakespeare, who knew almost everything, has already reminded us that the web of a spider is good for a finger-cut.

* Kirby.

But if we go on at this rate we shall spend all our time in the study of nothing but spiders. We have seen, now, something of the spider's web in one "revelation;" let us conclude with a reminder of what is said about it in the other.

The spider is mentioned three times in the Bible: first by Bildad (Job viii. 13—15), which, following the original, reads thus:—

> "Such are the ways of all that forget God!
> So perisheth the ways of the hypocrite!
> Thus shall his support rot away,
> And the building of the spider be his reliance;
> And upon its building shall he lean, but it shall not stand."

Then, secondly, by Isaiah (lix. 5), where the wicked are described as "weaving the spider's web,"—building, that is, upon something which the slightest disturbance will destroy. And then, lastly, by Agur (Prov. xxx. 28), where we are taught to blame ourselves for the consequence of self-neglect, and our despising the worth of the things that are small.

By the first two references I am singularly reminded of the truth of the Bible, in a remarkable instance of a spider, whom its Divine Author employed as an instrument of retribution; an illustration not only of the two texts above quoted, but another, namely, "Be sure your sin will find you out" (Numb. xxxii. 23).

A man who had a secret desire to get rid of his wife, determined to destroy her with poison, which he introduced into her food at one of their meals; but not having the courage to sit at the same table with her while she swallowed the fatal meal, he left for a few minutes. In the mean time a spider found its way on to the table, and crawled upon the poisoned food; and the wife brushed it away, not caring to eat that which the creature had

touched, and, supposing that her husband would know nothing of it, changed the food from her own plate to his; and on his return he actually swallowed the poison which he had prepared for his wife, and thus became the victim of his own wicked design.

Let us interweave the three references already quoted into one pattern, and, refusing to believe in what is called "chance," remember the fourth, and believe rather with our great dramatic poet, that

> "There's a divinity that shapes our ends,
> Rough-hew them how we will."

CHAPTER V.

BOTANICAL: THE LOWER ORDERS.

"Reject the society of the vicious; shun the agreeable infidel and the accomplished profligate. Lay it down as a fixed rule, that no brilliancy of connection, no allurement of rank or fashion, no agreeableness, no wit or flattery, shall tempt you to associate with profligate or openly irreligious men. Make this an absolute rule. It is impossible not to suffer by its neglect. If you do not fall into their vices, still your heart will be estranged from the love of God."—GRESLEY.

WE are again literally "embarrassed with riches," and when we look at the drawers in our cabinet marked "Botanical" we are puzzled to know where to begin; but as all life begins in an egg, and an egg and a seed have been seen to be so very nearly alike, not only in principle but in structure, let us renew our comparison of one with another. We have already thought upon this in our brief reference to the eggs of insects; let us now think more about it in our inspection of the beautiful structure of the outside of the seeds of many of our humblest plants.

An old writer says, "There is a strong analogy between insects and plants. The latter originate from a seed which is nothing but a husk, in which plants, however large they

may be when grown, are found entire; insects issue from an egg enveloped in its shell, which encloses them in all their proportions. Plants grow daily by the accession of alimentary particles; insects are developed, swell, and increase by means of a nutritive juice. Plants at first put forth a stem, and afterwards clothe themselves with leaves; insects begin by appearing in the form of a worm, and then acquire wings. The leaves of plants are full of nerves, which divide into a multitude of ramifications; the wings of insects have likewise a vast number of similar nerves. Leaves differ from one another in form and in the sinuations of their margin; wings likewise are varied by their configuration, and by the manner in which their extremities are indented. Plants push out flower-buds; insects become nymphs and chrysalids. As those buds, after having flowered, give fruit in their maturity; nymphs and chrysalids, after a certain time, produce perfect insects. Lastly, as fruit contains the seed proper for perpetuating the species of plant which produces them, insects, when arrived at their state of perfection, carry also within them the seed from which similar insects are to be generated." *

Many of our common garden-flower seeds might well be placed in comparison or contrast with the eggs of some of the commonest of our moths and butterflies. As a good judge will always tell the name of the painter when he looks upon one picture on comparing it with another, so the same handiwork is visible and the same artist recognized in the exquisite sculpture which these beautiful eggs and seeds have for the external envelope which encloses the germ of a future life.

Seeds belong to flowering plants; but plants that are flowerless, and do not, therefore, bear seed properly so

* M. Lesser (1799), in "Insecto-Theology."

called, bear instead, in the most exquisitely contrived envelopes, "spores" (from the Greek *spora*, "a seed"): these are minute grains, the beauty of which could never have been discovered but for the aid of our microscope. The spores perform the function of true seeds, amongst ferns and mosses, and many cryptogamic plants, which, with mushrooms and other fungoid growths, compose the lower orders of vegetable life, often bearing fruit more than a thousandfold, yet without producing any apparent blossom.

And that we may begin at the right beginning of our chapter, let us pause as we learn a lesson from what we may call "the natural history of the lower orders of vegetable life."

The "lower orders" have always played a conspicuous part in the interest of life, to whatever species they may have belonged. From the various specimens before us we shall learn much that, while it attracts our attention and astonishes our minds with the care God has taken for the humblest work of His hands, has also a lesson for us to learn; for just as there are "tongues in trees," so are there voices from the lower orders coming to us equally with those of a higher and nobler family, all speaking the same language as the stars, and joining in their grand Hallelujah chorus, "The hand that made us is Divine."

Look, then, at the spore-case of a garden fern. The edge of the frond is ornamented with a yellowish-brown border neatly running from the base to the tip. We have taken a small piece of this frond to show you the process of fructification. We put it in our stage forceps; then, placing the forceps in the appointed place, throw a strong light from our lamp through the bull's-eye lens on to the stage. Behold!

Ah! you may well exclaim, as a pious astronomer once did on surveying the starry heavens, "What omnipotence!" The power of God is seen just as much in the formation of a seed as in the formation of a sun; for, after all, is not a seed a tiny world? And is not the embryo contained in it its inhabitant, "whose seed is in itself," mysteriously wrapped up, generation after generation, so that generations yet unborn do lie concealed under that exquisitely sculptured envelope?

"Nothing can be more ungrateful," says worthy Mrs. Trimmer, "than to pass over the works of God without consideration. To study them is among the highest gratifications the human mind can enjoy, provided the study is conducted upon religious principles. The book of nature is open to all. On every leaf, 'Creator, God,' is written." If our dear poet Wordsworth could write, looking upon London as seen from one of its bridges—

> "Dull would he be who could pass by
> A sight so touching in its majesty"—

much more may we be affected in contemplating the works of God, which, He says, "ought to be remembered," and which, in the lowest and meanest and humblest conditions of life, as well as the noblest and highest, give such unmistakable evidence of design.

Fern (*Polypodium*), with fructification.

Now, look closely upon the sporules, that is, the spore-cases, of our fern. The heat, condensed by the convex side of our lens, has produced what may be called artificial hatching. Look! the case has

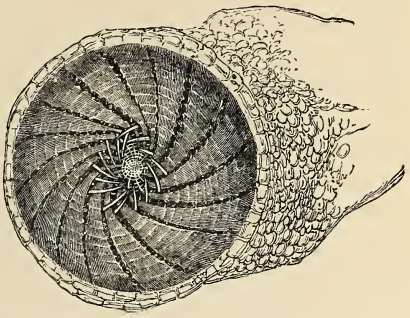
burst, and its contents are scattered in all directions. How was this effected? What secret spring was employed for this purpose?

Look at this preparation of one of these spore-cases from a small frond of Adiantum. The fleshy parts of the envelope which contains the spore-case have been carefully removed, and the empty cases, in their true colour, are seen; and there, concealed in the centre, are the mechanical springs—twenty we count in one case, not the twentieth of an inch in diameter, each spring containing upwards of twenty coils of exquisitely contrived material; and it is the sudden yielding of this, which is held together by glutinous matter, that, releasing the spring, sends the beautifully shaped spores in any direction the wind may take them.

The two beautiful families of ferns and mosses, you must know, are not to be included in the lowest orders of plant life. Ah, no! they are of a much higher order, but are mentioned here as giving you a practical illustration of the admirable contrivance in such plants as have no woody tissue, and which therefore require some special arrangement for the dispersion of their seeds. The motions in plants afford to the student of nature one of the most interesting of all the chapters in the study of botany; and we cannot have it better illustrated than in ferns and mosses; and while we are so doing let us show you how this operation is performed.

Here now is the spore-case of one of the commonest of our field-mosses, *Funaria hygrometrica* ("a measurer of moisture"). The spore capsules of this species are closed at their summits by what are called Opercula (from the Latin *operio*, "I cover over"); and a more beautiful object for the microscope, or a better illustration of design in so humble a thing, it is difficult to conceive,

The spores are held in the case by a beautifully contrived peristome, as it is called (from two Greek words, *peri*, "round about," and *stoma*, "a mouth"). Our object is mounted in a deep cell, and covered with a movable glass lid, so that, when uncovered, the light from our lamp can be thrown on to the object; and from the convex character of the lens, with the increased light, there is an increased amount of heat. Now, what this little moss would have required in its living form for growth and fructification was light, heat, and moisture. I wish you to know that it is fully five and twenty years since this specimen was mounted for me, and yet its motion has been, and still is, preserved. Let me show you what I mean. While you look down our magic tube, I will gently breathe into the capsule, and you will find the toothed mouth gradually open to disperse its hollow contents—always ready, you see, for its work. My breath, you know, contains both the properties, namely, heat and moisture, the moss would have required; and it is very remarkable that, after so long a time, this speck in creation should be so ready for its work. It reminds us of the motto of Lord Napier, "*Ready! ay, ready!*"



Mouth of the capsule of a moss (*Funaria*), showing the orifice of seed-vessel.

One more illustration of the admirable arrangement by which the embryo of the plant—the future life, that is, wrapped up and concealed in the seed—is protected, and the means employed for its release,

Here is a small seed of a garden plant called Collomia. Moisture, again, is the necessary element employed for the release of the embryo, which lies in the body of the seed hidden as the soul does in the body of man. Now, let me remove a very small portion of this little seed, and, placing it on a slip of plain glass, while you are looking down the microscope, put one small drop of water on the slide. Immediately it comes in contact with the embryo, a vast number of mechanical springs begin to uncoil themselves, leaping out from the surface of the seed. These springs are about the one five-thousandth part less in size than they now appear to you to be. The fibre of which these perfect pieces of mechanism are constructed is of the finest possible description, and the workmanship and contrivance are singularly characteristic of the most profound wisdom. Verily the works of the Lord *are* "great," but they *must* be "sought out," and that not by any careless observer, but by "those who have pleasure therein."

Now we shall get some small idea how it is that spores of plants, which compose what we have called the lower orders of vegetable life, are conveyed into the strange places in which they are discovered.

Have you ever observed a house-fly fastened on to a pane of window-glass during the latter part of summer? Did you wonder at its prolonged position? and did you, on going close to it, find it quite dead and fastened on to the glass, surrounded by a faint halo of greyish matter? That fly, a poor *Musca domestica* (the common house-fly), was destroyed by a vegetable, the spores of which, entering its body, multiplied with such amazing rapidity, that at last, living upon the fly, the end came; and then the animal making a last effort to live, as is so commonly done, it clung to the glass with its sucking tongue, while

the fungus, filling the animal's body, burst through the thin wall that concealed it, forming that ring which encircled the victim. This *Empusa muscæ*, as botanists call it, is one of the poorer classes, in the lower orders, that is, of vegetable life—a parasite, that loves to feed at the expense of the common house-fly. So rapid is the growth of some of the members of this family, that 4000 millions of them are produced in one hour, each one, though a simple and invisible cell, being a perfect plant.

You will be much interested during the autumn if you look out for this, our first illustration, upon the glass panes of your house windows. You will find the dead body of our friend so friable when you touch it that it will immediately crumble into dust, and yet, just before you do so, you will scarcely believe in its death—it so retains the attitude of life. You will observe that, unlike dead insects, who usually draw up their legs just before dying, crossing them beneath their bodies, the fly you are looking upon is supported upon its outstretched legs, its feet retaining their adhesive property in the exercise of the peculiar suckers with which this class of insects is able to hold on to glass; and, most remarkable, the wonderful tongue, to which your attention was directed just now, is extended, the empty shell being fastened to the window beneath it. The halo of whitish dust surrounding the body is composed of the spores of the fungus, which have so burst through the abdomen of the fly that the rings composing it are actually separated from each other—with such force did these curious things, with their united strength, release themselves. This dust which surrounds the body, with the aid of the microscope is found to be a true mould, and a fair specimen of that large class of unicellular plants to which so much attention is now being directed in the scientific world in

respect to the diseases to which we ourselves are subjected.

Now, let me show you another of my curiosities, which, had it a tongue, as Shakespeare fancies others of its family have, this is something like the story it would tell us:—

"'What am I,' did you say? Both vegetable and animal. I am a very small portion of a gift from New Zealand, made to my present owner, who is exhibiting my poor remains to you this evening, many years ago. Two of us came over in one ship: this is all that remains of myself. My brother shared a worse fate; for he suffered death twice, but I only once. Listen! In the land in which my family live there grows a wild fruit called by the natives *kumerea*, or sweet potato. We feed upon it, and we like it because of its sweetness. One day, while I was busily employed over one of these potatoes, the spore of a fungoid plant, which rejoices in the name of *Sphæria Robertsii*, having as great a fancy for my body as I had for the potato, found its way into my stomach with the food I was devouring. That *one* simple plant made not the slightest difference to me; I took no notice of it. But from what small beginnings do some fatal endings come! That one invisible thing very quickly gave birth to millions of others, and in a very short time the fleshy matter which came from the potato, and which had accumulated under the integument of my body, ceased to be. This formed a capital nidus for the growth of my enemy, and after that was consumed, all the softer parts were progressively consumed also, or assimilated, all which once formed the vital portions of my body; and these united and microscopic vegetables, after completely destroying my life, and so entirely filling up every nook and cranny under my skin, burst through it at the

weakest point—for, remember, caterpillars have *their* weak points, just as other animals that I could name have theirs—and, then, as if in triumph, seeking the outer air, the plant formed a strong woody stalk, rising above the surface, developing the spores which were dispersed in the air and then fell to the soil, prepared to take advantage of any other caterpillars who might, unfortunately, fall in their way."

Such would be the story of this "vegetable caterpillar," as the natives call it, which is a common object in New Zealand, and very well known there, belonging to a moth of the genus Hepialus.

"A romance," do you call it? Yes; but you have only heard one-half of the story. Let me tell you the other half.

First, let me prove to you the truth of what you have heard. Now, we place this section of this vegetable caterpillar under a low power. See, that long spiral line forming a mechanical spring, so freely running over the object in every direction, is all that is visible of its animal remains, except that darker spot; and these two are verily the trachea and spiracle of the caterpillar, for which, I suppose, the plant had no fancy. But the romantic part of this story has yet to be told. Many years after I received these two caterpillars, having fastened them up securely in a pasteboard box, tying it round with string, one day I thought I would have a peep at them, when, on opening the box, to my astonishment, while one was perfect, exactly resembling the outward form of the creature whose body was a vegetable museum, its fellow had gone to dust, in which were some broken bits of the outer skin.

No one had touched the compartment of the cabinet in which the box had all these years been lying. How

could the dust have come there? and what could have become of the body? That was *the* question. So I exposed this apparently inanimate dust to my microscope, and you may guess the surprise I felt in beholding this dust to be a mass of microscopic beetles. Like good old King George when he saw the apple in a poor woman's dumpling, I couldn't help asking myself, "How did it get there?" I can only suppose that the eggs from which these almost invisible beetles came must have been deposited in or upon the potato, passing through the various stages of life and growth, just as seeds do, which so nearly resemble insects' eggs, not only in form but in their life-history; and that, for all the intervening years, this colony of brothers and sisters, and fathers and mothers, and grandfathers and great-grandfathers, from whom they came, had been feeding upon that vegetable caterpillar. But the romance in this story of vegetable life is not even yet ended. I took one of these living beetles to a very dear friend, now in heaven, to whom I have been greatly indebted for some of the beautiful diagrams which have been so helpful in my lectures, and whose friendship was one of the many precious results of those lectures, just for the purpose of having its portrait taken; and you may guess its extreme minuteness and delicacy when I tell you that my friend accidentally killed it, after taking a drawing of it, by simply turning it over with the soft brush of a camel-hair pencil. But *that* is not all.

In Dr. Carpenter's valuable book already referred to, "The Microscope and its Revelations," there is an interesting description of such fungoid vegetation in insects as I have described, with woodcuts showing what things there are in the world that are not dreamt of in our philosophy; and he mentions a case under examination in

which such beetles as I have described, on being opened, have been found to be inhabited by a still smaller fungus.

Nor must we think that we ourselves escape. What is diphtheria, ringworm, what we call "consumption" (phthisis), cancer, and other fatal diseases? Dr. Carpenter tells us, in the work I have mentioned, that a disease of the scalp, in which yellow crusts are formed, consists almost entirely of the mycelium, receptacles, and spores of a fungus, and that the like is true also of those white patches on the lining membrane of the mouth of children which are known as "thrush."

It will amuse you if I relate a story in which I was the chief actor—one of the many singular results of my adventures in lecturing. Some years ago a doctor who attended my family invited me to give one of my lectures to the members of a well-known dispensary—now a hospital—in my own neighbourhood. I declined, remarking that it was simply presumption; but he pressed so hard that I accepted the invitation. The subject required was to be one that should bring all the members, every one of whom were doctors of medicine or surgeons, together; so I gave out the subject with a highly attractive title, adding that it was an argument for the further use of the microscope in disease. Well, the evening came, and I, taking care that I would say nothing I could not prove, armed myself *cap-à-pie* with diagrams and microscope, and, when all was over, a well-known M.D. said he had an interesting case of death the day before. A child had died of diphtheria, and he thought it a good opportunity to examine the disease with my instrument; and, neatly folded up in a napkin, he had brought down some matter for my examination, taken from the trachea.

I wished that I was anywhere but in that lecture-

room that night, I assure you. However, remembering that "nothing venture, nothing have," I thought I would look into the disease. A well-known M.D. prefixed his remarks by saying, "I don't think you will find any organic formation at all in it." So, spreading out some of what bore the appearance of clotted cream on a slip of glass, and using the highest magnifying power I have, namely, the very best one-eighth, that magnifies 400 diameters, that is, 160,000 times, it appeared to me that between this disease and these fungoid plants to which I have been referring there was little, if any, difference, each ultimate particle—invisible, of course, to the eye without the aid of the microscope—being a small circle with another generation inside; that, in fact, it was *nothing but organic formation;* and I said so. A smart discussion followed, and the end was that I discovered they took *me* for an M.D., and in their happy ignorance, in which I, mischievously, did not undeceive them, they made me an honorary member of the dispensary!

Innumerable instances might be here recorded of one thing living upon another; and while describing the very interesting illustration of the vegetable caterpillar, I remember a similar case of the mysterious way in which eggs, like seeds, find their way into places and things that puzzle our minds exceedingly.

Some years ago I was shown a large case of various descriptions of flies deposited, *for safe keeping*, in the hands of one of the first opticians in London, during the owner's absence abroad. The case, when I saw it, represented its appearance on the owner's return when he went to claim the property, on which he set great value.

What a scene! Swinging on the pins on which the specimens had been so long impaled, fastened to the cork below, were nothing but their skeletons; the Dermestes,

commonly known as the "bacon-beetle," had somehow or other got into the box, and had produced such an enormous family that the entire collection was destroyed, leaving the remains as a witness of what may be the consequence of a single act of incaution.

Again, I remember, among many other instances, how that one whom I well knew was surprised at finding the boards of the floor in his little parlour lift up the carpet which covered them; and, on removing both, he found, to his amazement, that the soft heads of some rhubarb plants, waking up to their usual spring-time work, had been left in the earth which formed the "foundation" of the house, the boards being laid only a foot or two from it, and *they* were actually the cause of the removal of the floor.

Again, in the city of Gloucester, it was observed that the thick paving-stones of one street of the city were, one after another, split, as if some mischievous fellow had wantonly damaged them while men slept. On lifting them up, guess the surprise on finding the stone-breaker to consist of a vast number of fungoid microscopical plants, whose united strength had produced the breakage.

But still again; another friend, a shipbuilder, came to me one day, and said he had noticed the gradual removal of the big logs of timber that lay in the yard, and after wondering what could have shifted them from their position as they lay on the bare earth, he changed the place of one, and found beneath a white mass of soft fibrous matter growing, which, when he brought me a specimen, I found to be a mass of fungoid plants, so firmly joined to each other that their interwoven mass resembled thick grey felt.

Do you know what "dry-rot" is? Another of my friends, standing on the naked boards of his kitchen, sud-

denly disappeared below, the boards letting him down. The woody tissue had been entirely eaten up by the small plant which feeds upon it, and is commonly called "dry-rot."

I do not know, in all my experience, of better illustration of the importance of little things than may be found in the ravages occasioned by this microscopic vegetable, known to botanists by the name of *Merulius lachrymans*, which in a few years will destroy some of the best and most solid-looking of houses. "The ships in the Crimea suffered more from this cause than from the ravages of fire or the shot and shells of the enemy. So virulent is its nature that it extends from the woodwork of a house even to the walls themselves, and, by penetrating their interstices, crumbles them into pieces." "I knew," says Professor Burnett, "a house into which the rot gained admittance, and which, during the four years we rented it, had the parlours twice wainscoted, and a new flight of stairs erected, the dry-rot having rendered it unsafe to go from the ground floor to the bedrooms. Every precaution was taken to remove the decaying timbers when the new work was done; yet the dry-rot so rapidly gained strength that the house was ultimately pulled down. Some of my books which suffered least, and which I still retain, bear mournful impressions of its ruthless hand; others were so much affected that the leaves resembled tinder, and, when the volumes were opened, fell out in dust or fragments." *

Surely these are solemn "lessons" to be read in such a revelation as this, which only the microscope could have explained.

Dr. Carpenter mentions that in the neighbourhood of Basingstoke a paving-stone, measuring twenty-one inches

* Quoted by Rev. H. Macmillan.

square, and weighing eighty-three pounds, was completely raised an inch and a half out of its bed by a mass of toadstools (which are fungi); nearly the whole pavement of the town being upheaved by the same cause.

The author of "Footnotes from the Page of Nature" tells us that "countless millions of the subtle seeds of fungi, invisible to the naked eye and light almost as the particles of vapour around them, are continually floating in the air we breathe, or swimming in the water we drink, or lying in the impalpable dust and sand of the soil, waiting but the combination of a few simple circumstances, the presence of warmth or moisture, or a suitable matrix, to display their vital energies, and to burst into full, free, independent life. Hundreds of thousands of the minute germs of the various moulds which approach us in our very houses, and fasten upon different articles of domestic use, might be, and often are dancing about in the air-currents of our apartments, though invisible to us; but could we sufficiently magnify them, as a sunbeam darted in at our windows and illuminated their bodies, they would appear like so many cannon-balls moving rapidly up and down, and in every direction.

"These countless myriads, then, of invisible seeds which continually float in our atmosphere, ever ready to alight and spring into life as the advanced heralds of the plague and the pestilence, may well strike us with astonishment, if not with awe. Above us, about us, and in us they roam like vigilant spirits, seeing after our physical constitution, but gladly availing themselves of the slightest flaw to work our destruction.

"Although fungi are in an especial manner capable of universal dissemination, yet we find that in their geographical distribution they are as much restricted as other plants."

Now, having preached a sermon to you, let us think of what may be almost called the comical side of our illustrations. Have you ever heard of the portentous growth of fungi in a gentleman's cellar, produced by the decomposing contents of a wine-cask, which, being too sweet for immediate use, was allowed to stand unmolested for several years? The door in this case was blocked up and barricaded by the monstrous growth; and when forcible entrance was obtained, the whole cellar was found to be completely filled, the cask which had caused the vegetable revel drained of its contents, being triumphantly elevated to the roof, as it were upon the shoulders of the bacchanalian fungus.*

What a picture of an irreclaimable drunkard!—despoiled, empty, and a nuisance!

We need not marvel at such romantic chapters in the story of a plant, when we consider the extreme minuteness of the spores of this description of fungus. The common puff-ball is said to contain ten millions, and these so small as to form a cloud when puffed into the air. A single filament of the blue mould which lives upon our bread, and especially upon fruit, will produce as many germs as an oak will acorns, each having in its microscopical cell the embryo of future generations. One of this family of puff-balls, the *Bovista gigantea*, occasionally to be seen in our fields and plantations, will increase in one night from the size of a pea to that of a melon!

Philosophers tell us there are hosts of these germs; some call them "microbes," the seeds of minute fungoid plants, which fly about in all directions, propagating diseases. Evidently, however, under ordinary circumstances, many pass off harmless.

Don't ask me, "Why, then, were they created?" 'Tis

* Hugh Macmillan, in "Footprints from the Page of Nature."

enough to know that everything created is a servant of Him who is the Creator, and the more we know of *Him* the more we shall believe in His goodness. They have their part to perform in the drama and system of life, and we must wait for clearer light. When the mists are rolled away that now keep us from distinguishing between good and evil, we shall understand what appears to be

Diatoms, shown with dark-ground illumination.

mystery. *Now* we know only in part; *then* we shall know even as we are known: so writes Paul.

Passing from this part of our subject, let me call your attention to the first letter of the botanical alphabet when we rise above the great fungoid family.

Here are many specimens of that wonderful class of true plants known to microscopists by the name of diatomacea, which are the peculiar property of the micro-

scopist, for without his instrument they would certainly have remained unknown. Nothing can exceed their great beauty, though many are not so large as the point of the finest needle.

Look at this, and this. Here is another Arachnoidiscus (that is, the spider-web disc): does it not remind us again of our spider-story? And do you not admire the structure of this wonderful skeleton of a unicellular plant? for it is nothing more, the fleshy portion having been removed by nitric acid? It is formed entirely of flint, and is a very interesting episode in the story of a pebble. Huge volumes have been, and will continue to be, written about these wonderful plants. "They open up to us the infinitude of microscopic life; they reveal a vast and glorious realm of new creative design, whose limits can never be fathomed, and whose mysteries can never be exhausted by man's finite researches. It is not so much what they actually disclose that awes and astonishes us, as the bewildering boundlessness of the unknown arcana beyond, to which they point. The vast additions which they have made to our knowledge have only left the immensity of the universe of life greater and more mysterious than before. For it is almost certain that, if our vision could be made more piercing, and our instruments more perfect, while we explored onwards through the successive realms of the invisible towards the inmost shrine of nature, we should find new scenes of wonder and beauty continually unfolding themselves, and new fields of omniscient display constantly revealing to us that God was still before us in all His exhaustless, creative energy, and that we saw but 'the hidings of His power.'"

These are the beautifully expressed thoughts of a devout student of science, the author of "Bible Teachings

in Nature," a book which I heartily commend to all who would "look from nature up to nature's God."

"Many are the important lessons which may be drawn from the study of plants when prosecuted in the true spirit of wisdom. The volume of creation is then made the volume of inspiration, and the more that each is studied, the more shall we find occasion to observe the harmony that subsists between them. It is only Science falsely so called which is in any way opposed to Scripture. The more minutely we examine the phenomena of the material world, and the more fully we compare the facts of science with revealed truth, the more reason shall we have to exclaim, in adoring wonder, with the Psalmist of old, 'O Lord, how manifold are Thy works! in wisdom hast Thou made them all; the earth is full of Thy riches'" (Professor Balfour's "Manual of Botany").

CHAPTER VI.

BOTANICAL: THE UPPER CLASSES.

"Blessed is the man that walketh not in the counsel of the ungodly, nor standeth in the way of sinners, nor sitteth in the seat of the scornful. But his delight is in the Law of the Lord; and in his Law doth he meditate day and night. And he shall be like a tree planted by the rivers of water, that bringeth forth his fruit in his season; his leaf also shall not wither; and whatsoever he doeth shall prosper."—DAVID.

WE are now to explore some of the invisible regions of the upper classes of vegetable life, and to ponder over the structure of a few of the inhabitants of the invisible world with the necessary aid of our instrument. Let me tell you that much patience as well as perseverance will be necessary, and we must learn how to take advantage of every description of illumination; for it is equally true of one of God's revelations as it is of the other—everything depends upon light. We may fail in discovering some of the profoundest of His secrets through ignorance of the way to the purest light; or, we may be blinded with an excess of light. The same principle holds true in the Word of God as in the works of God, and the devout student of Scripture, as well as the thoughtful lover of the microscope, has continually to say, "In Thy light shall we see

light." Each is a revelation, and we not only need a right spirit to receive the secrets of His Word, but a right understanding to penetrate into the mystery of His handiwork.

We want the simplicity of little, loving children in order to receive from the great Teacher the secrets of what we call "nature," and to remember the words of the Master, "I thank Thee, O Father, Lord of heaven and earth, because Thou hast hid these things from the wise and prudent, and hast revealed them unto babes," before we can see into the supernatural. Nature is a nurse who has her glorious pictures ready for such of her children as have eyes to see, reminding one of the simple but beautiful lines with which some of us are familiar—

"For Nature, the old nurse, took
The child upon her knee,
Saying, 'There is a story-book
My Father has written for thee.

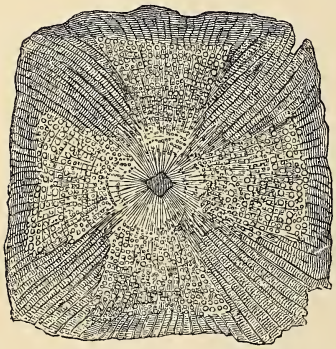
"'Come, wander with me,' she said,
'Into regions yet untrod;
And read what is yet unread
In the manuscripts of God.'

"And he wandered away and away,
With Nature, the dear old nurse;
And she sang to him night and day
The songs of the universe."

Now we have a choice object. It consists but of three small leaves of the common box with which we border the beds of our gardens; in it we have a typical representation of all leaves. And what a wonderful thing, truly, is a leaf! and more wonderful still is a plant, whereas a full-sized forest tree, one of the very commonest of all God's works, is a standing monument of His Almightiness!

When we think of the variety of form, and taste, and colour, and produce of trees, the sweetness of one and the

sourness of another; and then consider that all seem to grow in the same manner, from the same soil, very often on the same spot; that they all breathe the same air, drink the same water, and digest the same food, and all so silently, so steadily, so invisibly;—what lessons may we not learn from their delightful study! and what solemn thoughts do they suggest on the mystery of growth!



Transverse section of a New Zealand plant.

Their inward structure is as regular and various as their outward forms are elegant and well-proportioned, while many suggest devout thoughts concerning the sign of man's salvation—the token of the new covenant—the Cross.

Their formation cannot have been originally designed *merely* to attract the eye of an accidental spectator, but rather to render the production more perfect in its appeal both to the senses and the soul. The root, trunk, branch, leaf, flower, fruit, and seed have each a peculiar character as well as a special mission, the wonders of which can only be fully revealed by the microscope. Thus viewed, they appear to vary in an endless diversity, each working for the same end and by means of the same law. No part in either the smallest leaf or the most minute fibre but what is formed with the most exquisite exactness and consummate skill.

What a mystery is growth! "The man who does not care and ceases to grow becomes torpid, stiffens, is in a sense dead; but he who has been growing all the

time need never stop; and where growth is, there is always a capability of change. Growth itself is a succession of slow melodious ascending changes." * These words apply both to trees and men, and one is strikingly illustrative of the other.

Verily there is very much in the life of a tree that reminds us of the life of a man, and not only of a man, but of other animals. Several of that wonderful family Orchidaceæ resemble, one a wasp, another a bee, another a spider, a fourth a fly, and another resembles the dove, which is often figured over the head of the Saviour, descending at His baptism, enjoying the name of "Spirito Sancto," or Holy Ghost flower; others are like large and brilliant butterflies.

Then, if we examine the structure of any one of the plants, we shall find how nearly it runs parallel with that of an animal, from the circulation of the vital fluid to the solid limbs and the outer covering; and the lessons they teach are as many and as varied as are their forms and their beauty. But now we have to do with their internal structure, and the object upon the stage of our instrument will make this plain.

Of course, you are aware that plants *do* breathe; but do you know *how?* And do you know that while *we* inhale the gas oxygen (a word from the Greek *oxys*, "acid," and *gennao*, "I produce") from the air, plants inhale carbon (a Latin word signifying "coal," because every bit of true coal was once part of a plant)?

That which we *exhale* (carbon as carbonic acid) they *inhale*, and the spirit of giving and taking is nowhere more beautifully taught us than in what we see in the life of a plant.

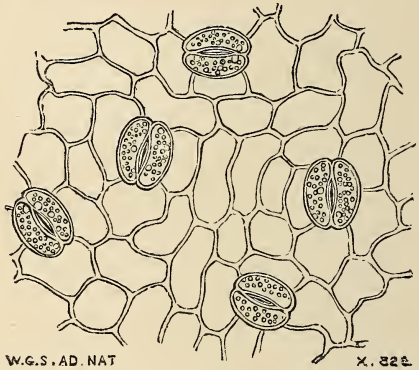
Now, in these three little box-leaves, which do not

* Dr. MacDonald.

measure more than half an inch in length by a quarter of an inch in breadth, you will observe a vast number of little openings lying over the whole of the skeleton; for you must understand that the fleshy part of these leaves has been removed, that we might learn how a plant breathes. Wordsworth sings as a poet—

> "And 'tis my faith that every flower
> Enjoys the air it breathes."

I cannot tell you whether a flower enjoys sensation. I *can* tell you that it possesses the virtue of punctuality; so



Portion of leaf, showing cellular tissue and stomata.

much so that a floral clock has been constructed, composed of English wild flowers, arranged on the principle of the rest, or sleep, which all plants are known to take every twenty-four hours, each flower, being suspended over the figures on a dial, opening or closing punctually at the time indicated by the hour. I can tell you also how very nearly these little openings on the epidermis of our box-leaves resemble the air-cells in your lungs and mine, in which as many as 600 millions have been reckoned, distributed amongst 18,000 air-tubes. Equally

characteristic of the Creator's wisdom are the air-cells in a plant; and those in the leaf before us, you will see, are countless. One harbinger of summer is the lilac. How plentiful is its foliage! how sweet the well-known blossom it produces! and what early associations of youth are brought to mind year by year, if only in our father's garden there happened to have been a lilac tree!

In one square inch of a lilac leaf there are no fewer than 160,000 of what are called stomata (from the Greek, meaning "*a mouth*"). They are formed by two half-moon cells, the cusps of which unite around an oval orifice, which opens and shuts exactly as do the millions of air-cells in our lungs; and these, observe, are spread over the entire epidermis, that is, the external cellular covering. In the skeleton of one of these three box-leaves, mounted, not to show stomata, but the midrib, and what may be called branches of the leaf, we see a true representation of our own skeleton. That midrib is an analogy of our great backbone — the vertebral column—the main trunk of the nervous system, which conveys the messages we send to the most distant of our bodily members from the great central telegraph-station, the brain. Let us employ our highest magnifying power, called a sixth, which

Skeleton of black poplar leaf.

shows us the object, with our first eye-piece, two hundred and forty diameters larger than it appears to our unassisted vision. Now, if we apply our *highest* eye-piece, this will increase our magnifying power, superficially, to near upon a million times, and now we can penetrate into, not only the concealed mystery of this midrib, but the minutest of branches. And there, in this "common object for the microscope," what do we behold? The most exquisite chain of cells and forms of beauty that our minds can conceive; and exactly as our backbone is divided into partitions with a great central canal protected on every side that the pulpy mass of nervous matter may not be injured, so here, in this tiny leaf, is the same evidence of anticipation of a want, which none but the all-wise Creator could supply. Verily the Supreme Being would appear to have exhibited more of His magnificent wisdom in the smallest of His works than in the largest!

And then, following up the analogy of the skeleton of a leaf with that of a man—its method of breathing, and working, and sleeping—let us pause to think of the number of times men are compared to trees in the Bible —upwards of three hundred, it is said—the text at the head of this chapter being typical of them all. You may be familiar with the words of Isaiah, "As the days of a tree are the days of My people" (ch. lxv. 22), and with those of Moses, "And the tree of the field is man's life" (Deut. xx. 19)—such words as these remind us of the relation of animals to vegetables, and assure us that He who made and cares for the humblest of His plants will not forsake His children, just as a good father will care less for his pictures than for his offspring. And we are also reminded of the wonderful words of love of the great Teacher, "If God so clothed the grass, . . . will He not

much more clothe you?" supplying all your necessities for both worlds.

Yes, just as we may usually see on the best of watches the name of the maker, so may we, if we will, see the private mark of the Creator on the humblest of His works, even as we are trying to do on these little leaves, which measure only half an inch in their length, and half that in their breadth.

When Apelles, the Greek painter, called on his friend Protogenes, and found him absent from home, he entered the studio, took the pencil which had been kept ready for the master's use, and made one straight line with its point on the unfinished subject. When Protogenes returned, he exclaimed, "Apelles of Cos has been here!" He recognized the artist in the faint line he had left behind. And may we not recognize the hand of the Creator in His handiwork, when we observe the same principle employed in either branch of the natural world?

Siliceous skeleton of Deutzia.

Here are all sorts of leaves awaiting our examination. The Deutzia, from which all the fleshy part has been removed, and, like the beautiful skeleton last examined, with nothing but the framework left. Here, again, we have an analogy, but not as between a plant and an animal, but between a plant and the starry heavens; for the framework of this plant consists of a host of microscopic stellate forms of exquisite beauty, and when this object

is seen under polarized light for which it has been specially mounted, and we get a bright blue background, with these siliceous crystals in the foreground in a brilliant golden colour, the resemblance to the heavens on a clear night is very striking. This skeleton is insoluble, being formed entirely of flint, which mineral is abundantly distributed amongst plants. If we examine the ashes of hay or straw after they have been burned, small lumps of what appear to be dirty glass will be found mixed up with them. This is caused by the fusion of the flint (silica) contained in the cuticle combining with the potash in the vegetable tissue, forming what is known as "silicate of potash," the scientific name for glass. And this was how glass was first discovered.

In the midst of the cellular tissue of almost every leaf you will see a number of minute crystals called *raphides* (Greek, "needles"). These are beautiful formations, sometimes of phosphates or tartrates, sulphates or carbonates. They are the medicinal properties in all plants. In the onion they are oxalite of lime; in the apple, malic acid. And here I should like to call your special attention to the medicinal property of an apple, which is a chemical composition of albumen, sugar, gum, chlorophyll, malic acid, gallic acid, lime, and water, mixed up in vegetable fibre. It is said that the apple contains a larger percentage of phosphorus than any other fruit or vegetable. This phosphorus is admirably adapted for renewing the essential nervous matter of the brain and spinal cord, for rousing sluggish livers, for neutralizing the effects of unwholesome food, and for the dispersion of chalky matter engendered by eating too much meat; and for diminishing acidity in the stomach, apples are the finest of all medicines. A good ripe apple is one of the

easiest of all vegetable substances for the stomach to deal with, the whole process of its digestion being completed in eighty-five minutes.

A poultice made of rotten apples is of very common use in Lincolnshire for the cure of weak or rheumatic eyes; and in Paris roasted apples applied over the eyes, without any intervening substance, in the form of a poultice, is of common application; and an old maxim teaches that—

> "If you eat an apple going to bed,
> The doctor then will beg his bread."

Now let us examine this section of Turkey rhubarb. It contains abundance of raphides of a very strong dissolvent oxalite of lime, forming the chief ingredient of the onion, the crystals of which we shall see abundantly stored up in its cuticle, and which give to it its peculiar flavour; but besides this chemical, rhubarb contains tannin, gallic acid, resin, and other chemicals, forming 36 to 40 per cent. of its substance. The structural likeness between men and plants is remarkable in no point more than in their compositions. A man's body weighing 126 lbs. consists of 11½ lbs. of charcoal, 11½ lbs. of gas, 8 lbs. of lime, and 95 lbs. of water. Think of that!—that is, exactly two-thirds liquid. Or, it may be put chemically, that a human body of average weight consists of 45 lbs. of carbon and nitrogen diffused through about five pails of water; and yet when the body of a bulky woman was cremated in the Woking Cemetery three years ago, her corpse, weighing 200 lbs., was reduced to 3 lbs. when the ashes were collected.

Water forms the chief ingredient of plants, as it does of man, and the Turks are correct when they place over their beautiful fountains the quotation from the Koran, "Everything lives by water."

Potatoes contain 75 per cent. of water; turnips and carrots, 80 per cent. A sunflower plant consumes twenty-two ounces of water daily. Three million pounds weight of water, it has been said, would be required for an acre of sunflowers; five millions for an acre of cabbages; six or seven millions for one of hops. Through the agency of this vital fluid plants take up all the elements of their composition, and much is absorbed from the earth through the roots. Now you will understand why last summer (1890) we have had such a wonderful growth, if you remember the gracious showers which have fallen.

Experiments made with the grain and straw of oats have given the extraordinary result of eleven different descriptions of inorganic matter assimilated into the life of the plant from the soil and the air, weighing (in 1000 lbs.) nearly 26 lbs. in the grain, and 57½ lbs. in the straw; and this wonderful combination of eleven inorganic substances includes potash, soda, lime, magnesia, alumina, oxide of iron, oxide of manganese, silica, sulphuric acid, phosphoric acid, and chlorine; and out of these inorganic substances 20 lbs. of the 26 lbs. in the grain, and 46 lbs. out of the 57½ lbs. in the straw, are found to be silica, that is, flint.

Now observe this cuticle of wheat-straw.* Only look at the exquisite formation of the siliceous crystals. How regularly they are arranged! how countless their number! and how beautiful their forms! Compare them with the Deutzia, and ask *why* such exquisite pains should have been taken with the variety of these flinty forms, which, but for the microscope, would never have been seen. And here, too, in the cuticle of the wheat-straw, we see the little stomata, or open mouths, which take in

* See page 252.

the moisture of the atmosphere, and, with the inorganic substances drawn from the two great sources, earth and air, produce our most necessary food. You will remember that in the lilac as many as 160,000 have been reckoned in a square inch. Let me take an average-sized leaf from the lilac tree in my garden, and measure it. See, it is $2\frac{3}{4}$ inches in length, by $2\frac{1}{10}$ inches in breadth. A careful measurement shows that there are $4\frac{1}{4}$ square inches in its composition, so that there would be upwards of 640,000 breathing mouths on this one leaf. What must be the total number on the entire tree? Verily a tree is a miracle.

An oak in Sussex was twice carefully measured, and its contents, trunk and limbs, accurately taken, and a correspondent of the *Standard* newspaper sent the following result:—

December 20, 1819	458 feet 7 inches.
May 11, 1867	661 „ 3 „

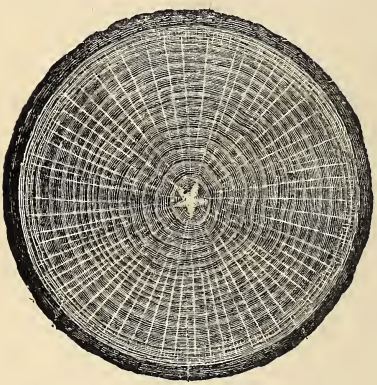
The circumference of the tree at one foot from the ground was—

December 20, 1819	20 feet.
May 11, 1867	28 „ 6 inches.
October 2, 1889	30 „ 9 „

Don't let us dismiss this part of our study without reflecting upon the variety and glory of a tree; remembering that a tree has a very striking resemblance to a man. The leaves individually fall and decay, but the tree survives, and the race is perpetuated. As "one star differeth from another star in glory," so one tree differs from another. "There is one glory of the oak, which looks as if it had faced a hundred storms, and, having stood them all, was ready to face as many more; another glory of the sycamore, that 'spreads, in gentle pomp, its honeyed shade;' another glory of the birch, so graceful in the

midst of its maiden tresses; another glory of the elm, throwing out its wide arms, as if rejoicing in its strength; and another glory of the lime, with its sheltered shade inviting us to enter and linger." *

Yes; and it is not upon the leaf of the lime and its sweet blossom only that the eloquent author might have written. Had he known of the marvellous structure of its stem, he would have been as much overwhelmed as you will be: no artist could do justice to it, for it far exceeds the beauty of the oak, and it is equally impossible to convey a faithful description of it in words. Here it is. Look at it! It is a section of the stem of a lime tree of two and a half years' growth, cut obliquely through the junction of a branch with the stem, in which there are no less than eleven different objects attracting our attention as well as our admiration. First, there is the pith, with its hexagonal cells, in which are grains of starch; then there are the numerous star-shaped raphides, dividing the cells of the pith into large, circular, oval spaces; then the sheath outside these cells, containing more starch-grains; then comes the first year's growth of woody fibre; then the second zone, for, of course, you know that the tree, like a man, leaves its mark upon every one of its years' growths; but, lastly, the most interest-



Section of oak, eighteen years' growth.

* Dr. McCosh.

ing part of this beautiful object is that where the formation of the new branch is seen showing bundles of spiral fibre and numbers of beautifully formed prismatic raphides.

Who would think of finding all these wonders in a "bit of wood"? Who, except my friend the honey-bee, would discover the sweet things which lie concealed in the blossom—which, remember, is merely the leaf perfected? We judge too often by appearances only. "Leaves," says Leigh Hunt, "seem light, and useless, and idle, and wavering, and changeable—they even dance; yet God has made them part of the oak. In so doing, He has given us a lesson not to deny the stout-heartedness within because we see the lightsomeness without." And, lastly, think: the oak and the beech and other of our forest trees owe their durability to their deep-rootedness;—so, if we are "rooted and grounded" in the soil of faith, we shall bring forth much fruit.

From leaves we naturally expect to pass on to flowers, and in such an examination what a feast will be prepared for our mental appetites!

Let me first offer a little advice as to the examination of flowers under the microscope. Better still, as it is the very prime of summer, we will suppose that I fetch a few from the garden, and regale your sense, not only with their aroma, but their beauty.

"*Consider* the lilies," said Jesus; and if we *do* consider, what an eloquent sermon shall we hear upon life, death, and resurrection!

"Yes, flowers have tongues. God gave to each
A language of its own,
And bade the simple blossom teach
Where'er its seeds are sown.
His voice is on the mountain's height,
And by the river's side,

Where flowers blush in glowing light,
In lowliness or pride,
We feel, all o'er the blooming sod,
It is the language of our God."

To examine a flower satisfactorily, we shall find a very low power necessary. *Our* object-glass will be a *four*-inch, that is, one magnifying only ten diameters, or a hundred superficial times; this will enable us to see right down into the flower of this heart's-ease just brought from the garden. Ah, you may well exclaim again, "*What omnipotence!*"

This flower I have cut clean away from its stem, and, placing it in the stage forceps, I throw a flood of light upon it through the side condenser—the bull's-eye lens—so called. And now we penetrate into the mysteries of the ovary; for there you can see it in the very bottom of the flower. But what words may express, what pen describe, or still further what pencil portray, the glory of the colour and form exhibited in this beautiful specimen of God's handiwork?

Now, let me gather one small head of the "little darling" (mignonette). Here, first, is a bit of this exquisite flower, to compare with that just gathered, sent me in a letter two years ago, though dried and its beauty greatly diminished. See how its surprising group of blossoms delights us still. And its perfume! why, that is preserved, though its life has long since departed. What a lesson! We also *must* leave an influence behind, and it is for us to decide whether that will be for good or evil.

You will not easily forget these two flowers I have thus imperfectly introduced to you, I am very sure.

What is commonly called the dust of any ordinary garden flower is known botanically as *pollen;* this is it which, by impregnation of the ovules, produces the next

generation of the species. In some blossoms their number is very great. It has been said that a single plant of wisteria has produced 6,750,000 stamens, which, supposing all to have been perfect, would have contained 27,000 million pollen grains. It is from these pollen grains that the bees, extracting the sweet matter contained in them, make honey, wax, and poison, and, by carrying the pollen of one flower to another of *the same species*, the object for which the insect and the plant were made to depend upon each other for their existence is accomplished.

Stamens, with pollen, of the common mallow, with enlarged figures below. Drawn from nature.

Here, then, you see the pollen of the common mallow. It grows by the river-side and in the cemetery, or in brick-fields. It is content with the humblest localities. But behold its glory! One mass of golden globes, studded with minute hooklets, so that it may adhere to the substance for which it was created: can anything be more beautiful?

The pollen of one branch of the family must penetrate the ovule of the other branch before there can be blossom. Some years ago, one of the Fellows of the Linnæan Society told me an amusing story of the introduction of red clover into New Zealand. The colonists knew that bees were necessary to carry the pollen from one flower to another, so with the seed they imported bees; but when the seed de-

veloped into plants, and the plants into blossoms, the blossoms all died off without ever being renewed, and, upon application to English naturalists, it was discovered that the *humble-bee* was the insect that had the red clover under its management. The *honey-bee* having been supposed to be the proper instrument, they had imported that bee with the plant, but were unsuccessful until the *humble-bee* was sent to them.

A very remarkable illustration, amongst thousands of others, is here exhibited of the adaptation of means to an end, proving the doctrine of design in one important branch, in the life of a plant.

There is an aquatic plant called *Vallisneria spiralis*, remarkable, among other things, for its usefulness to the microscopist as showing that marvellous thing, the circulation in plants. One day, being in the shop of a well-known optician, one of his friends came in, saying he couldn't think what had come to the Vallisneria in his aquarium—"it was all going to stalk!"

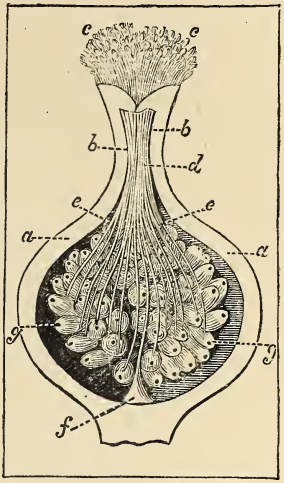
"Hereby hangs a tale."

The history of this humble plant affords us one of the most striking instances of design. It is a native of Italy, and is found in the waters of its rivers, and in those of the turbulent Rhone, and it has been introduced into our own country.

The pollen, borne always on the stamens and anthers of flowers, is their fertilizing ingredient. It is this fine powder which you have just seen in the common mallow, and which you must often have found in the lily when you have intruded your nose into its blossoms, and it has come out powdered with its fertilizing dust, which the bees would have conveyed to the pistil in their visits to the blossoms—both stamen and pistil growing together in the lily family

In the Vallisneria, however, the flowers which bear the stamens and those which bear the pistils are always on two separate plants, and unless some means are employed by which the pollen of one can be conveyed to the other, the family must inevitably perish.

A curious fact makes the history of this common plant unique in botany. The pistiliferous branch of the family rises to the surface by a very long and slender spiral stem, floating on the water like a water-lily, while the stameniferous branch, growing below, remains there, fastened to the soil right down under the water.



Fecundation of a sunflower; the ovary laid open.

a, a, walls of the seed-organ; *b, b*, walls of the pistil; *c, c*, summit, covered with grains of pollen; *d*, conducting tissue of the centre of the pistil; *e, e*, filaments from this tissue running to the nascent seeds; *f*, base of one of the walls of the verge; *g, g*, numerous nascent seeds placed perpendicularly on the verge (Rennie's "Alphabet of Botany").

I have told you that, unless the pollen of the stamen is conveyed to the pistil, no seed will be produced, and, as the two plants of Vallisneria have two localities prescribed for their separate growths, were no means contrived by which the pollen of one could be conveyed to the other, the family would become extinct, for between the flower above and that below roll the intercepting waters of the river.

It was Vallisnerii, the naturalist, who first discovered the wonders of this plant, and now we have to inquire how the difficulty is met. By a remarkable "*coincidence*" or "*acquirement*," as some would call it, the

flowering of one "*happens*" to come to perfection just at the same time as the other, and when the pistiliferous blossom floats on the stream fastened to its long stem, the stameniferous flower, developed in its obscure bed, leaves the dark earth in which it has been preparing for its aërial flight, and, rising from the main stem to the surface, there—just as a butterfly expands its glorious wings to the sun when it emerges from its prison-house in the chrysalis—unfolding its petals, the stamens are visible, and, wafted either by the wind or the air, or attracted by some mysterious and unknown influence, it finds—shall I say?—the object of its search, and, as the poet would say, after a loving embrace, it withers and dies.

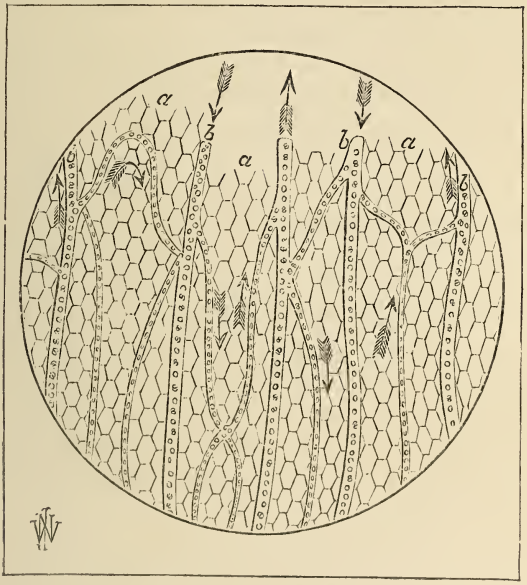
Now comes the second striking chapter in this romance of vegetable life. The surviving plant, with the pollen of its embrace, no longer remains on the surface. The long spiral stalk, which has obtained for the plant an addition to its name—*spiralis*—turned in one direction, *upwards*, now takes a contrary direction, and, having no further attraction there, again seeks its domain below; and, the long stalk gradually contracting, the blossom soon reaches its bed in the bottom of the river, where its seed, made fertile by its companionship above, strikes root, and a new plant is produced.* Well may a devout naturalist say, "We might challenge all botanical science to produce any series of phenomena so striking as this, or so satisfactorily demonstrating the skill and foreknowledge of the great Creator." †

The nearest comparison is the pitcher-plant, or, perhaps, several of the fly-catching plants; but as I have previously told you their story in another volume, I must not repeat it here.‡

* See Frontispiece. † P. H. Gosse.

‡ See in "The Autobiography of an Acorn; 'The Story of a Leaf.'"

There are those who would tell us, in the cold stony language of unbelief, that this was simply a "law of nature." To such I would say, "So it is; but tell me, who *is* what you call 'Nature'? Where does she live? To what country does she belong? Is not 'Nature' only another name for God?"



Circulation in a leaf.

To observe the marvellous circulation in a leaf, the Vallisneria affords one of the best of opportunities. A small piece should be cut vertically, then from the same piece a horizontal slice, and, when placed under a high power, the flow of the vital fluid will be seen, with proper illumination, after the manner of the cut above, in which the arrows show the direction of the currents; *a*, *a*, *a*, the cellular tissues; *b*, *b*, *b*, *b*, the vessels in which

the currents take place, whose direction is pointed out by the arrows.

Does not the existence of a law invariably prove a law-maker?

Would you really say, with the followers of Epicurus and Lucretius, and their modern disciples, that the *Vallisneria spiralis* had "*acquired*" its state of perfection simply because it needed it?

Our museums abound with specimens of what some consider proofs of pre-Adamite man, or, at least, of prehistoric humanity. Rudely carved implements in flint of various forms have been found at such depths in the earth that, without doubt, they are very ancient. They must have been deposited for thousands of years in the same place where they were first discovered; but if they afford evidence of one thing more than another, it is evidence of mind, of intelligence and intellect, in their form and fashion. But when we have such striking instances as those in the Vallisneria, or the pitcher-plant, or many other less attractive but equally humble plants, some men are miserably content with putting it down to "a law of nature," reminding us of Wordsworth's story of the boy to whom

> "A primrose by a river's brim
> A yellow primrose was to him,
> And it was nothing more."

How is it that some flowers close their petals while rain is falling, which would spoil or wash away the honey contained in their nectaries? It is "a law of nature." Why do other flowers close their beautiful eyes, and go to sleep as punctually as the clock strikes the hours? This, too, is only "a law of nature."

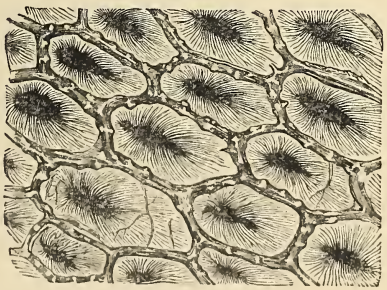
The flowering of plants takes place with striking regularity, so much so that, by observing the exact time

when our garden plants are in blossom, the several months may be known. How punctually does the snowdrop beautify the time of January; the violet, February; in March, the cowslip; in April, the daffodil; the great mass of plants in the leafy months of May and June; many in July, August, and September; the golden rod in October and November; and the Christmas rose in December! And from three in the morning punctually, hour by hour, until ten at night, do these wonderful proofs of God's love speak to us.

> "To me the meanest flower that blows can give
> Thoughts that do often lie too deep for tears."

Verily they must have had an admirable teacher to have "*acquired*" such goodly habits of order and obedience!

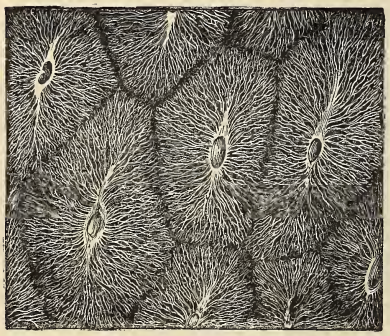
Here is one of the petals of an ordinary geranium, again reminding us of the analogy of plant and animal life. It has two skins, one of which has been peeled off the other to make the structure more transparent. With a power magnifying 176,000 superficial times, what do we see? A countless number of deeply interesting cells imbedded in a matrix begemmed with dotted tissue, the cells giving to the flower its colour, and having a central dark mass, from which a series of very fine lines is seen running to the extremity of the cell, of most interesting form and marking.



Cells from petal of geranium.

Reference has been made to the *contrasts* in nature.

Very interesting it is to consider the *harmony* of nature. The Divine Author has often given the same patterns of His workmanship in the animal that He has in the vegetable kingdom. For example, take the case of the Myliobates, one of the cartilaginous fishes, of which the common ray is the type, and to which family the skate belongs; its teeth are large, flat, and mosaic-like, and, when examined as an opaque object, exhibit cellular structure similar to the petals we have just had before us, which patterns have unconsciously been copied in many an article manufactured by man.



Transverse section of tooth of Myliobates.

Let me very strongly recommend you to study the most common of flowers, if you would know what a wonderful Workman God is. You *look* at them with your eyes, and, if you have a taste for the beautiful, you admire their loveliness; but you can only *see* their marvellous structure by means of the microscope. A low power, a deep eye-piece, good light, and a ready mind, and you will then discover the difference between *looking* at a thing and *seeing* into it.

I cannot resist introducing here an anecdote sent me by a friend during the compilation of these pages. He says—

"Two poor little children lived in one of the worst of the courts leading out of Golden Lane. They lived alone—no uncommon thing in such quarters as these.

The boy, twelve, sold newspapers; the girl, nine, lay sick upon a truckle-bed all day, sitting up only when her brother was at home. They had been born in the country, but now, there they lived in that stifling attic, with no sight of a green tree, and scarcely any of the sky, while the buttercups bloomed and withered, and the wild rose was in flower, and the hay was made, and the corn was cut, all round the cottage where they used to live.

"One day she said, 'Tom, do you think I could get out anywhere—just for once?'

"'Could you stand it?' said Tom.

"'I'll try,' she said.

"And that brave boy saw the shining in his sister's eyes, as he lifted her up in his arms and carried her down the stairs; and he carried her *all the way to the Thames Embankment*, about a mile away, and he put his dear burden down upon a seat just inside one of the garden gates, and, as she looked at the trees, and shrubs, and flowers, and green grass, she put her head on Tom's shoulder, and was overheard saying, very softly, 'Tom, it's heaven! it's heaven!'"

We are very unwilling to leave this fascinating part of our employment, but we have other paths yet to tread. And we must take our leave presently of flowers, with the remembrance of dear Mary Howitt's simple but beautiful lines, the very memory of which brings us back to our beloved boyhood—

"God might have made the earth bring forth
Enough for great and small,
The oak tree and the cedar tree,
Without a flower at all.

"He might have made enough, enough
For every want of ours,
For luxury, medicine, and toil,
And yet have made no flowers.

"Then, wherefore, wherefore were they made,
And dyed in rainbow light,
All fashioned with supremest grace,
Upspringing day and night?—

"Springing in valleys green and low,
And on the mountains high,
And in the silent wilderness,
Where no man passes by?

"Our outward life requires them not;
Then wherefore had they birth?
To minister delight to man,
To beautify the earth,

"To comfort man—to whisper hope
Whene'er his faith is dim;
For who so careth for the flowers
Will much more care for him."

But we must not say "farewell" to our botanical study without a passing glance at a few out of the large collection of *sections* before us. Here is one of the Wellingtonia giants of California. It is a triple section, showing the most beautiful variety of tissue in the woody bundles of fibres from which, in this class of trees, pulp is now made and is afterwards converted into writing-paper. The tree from which this specimen was cut is said to have been the largest in the world, growing to the astonishing height of 450 feet, that is, about one-eighth higher than the top of St. Paul's Cathedral. It was 112 feet in circumference. Looking at this interesting specimen, where all the fibres interlace each other, exhibiting the pitted ducts for which this class of timber is so famous, and which are test objects for the higher magnifying powers, what a world of beauty it must have been! One of this family was recently cut down by some ruthless hand, and, had it a tongue, it would have unfolded a tale which would have taken some time indeed to relate.

It was known by the name of "Old Moses," and was one of the most sylvan patriarchs of California. The annular rings which describe the age of a tree, one per year, amounted to 4841, so that its term of existence was a longer one than any of the world's known, or at least authenticated, history; it may have been a fine stripling when Noah built the ark. The hollow portion of its huge and massive stem afforded standing room for nearly three hundred full-grown men.

Now for another specimen of antiquity. "Imagination bodies forth" a long and profoundly interesting story while we are looking at the object before us, which is a section of a cedar of Lebanon, from an Assyrian palace at Nineveh, where it had been standing and lying for three thousand years. Shall we be more interested in the examination of its beautiful structure than in listening to its still small voice?

It came from the British Museum, and from the highest authority of the botanical department there we learn that when it arrived it still retained the odour peculiar to its nature; and *that* had been preserved for three thousand years, which carry us back to the time of David, Samuel, and Saul. Does it not supply us with a text for a sermon, "The memory of the just is blessed"? and does it not also remind us of the words of one in whose time perhaps it was placed in the palace of his country's enemy, "The righteous shall grow like a cedar in Lebanon," that is, shall be preserved for ever?

Here are sections of the *Pandanus spiralis*, the screw pine, reminding us of the tree associated with growth in the words just quoted, "The righteous shall flourish as a palm tree," that is, from *within*, whence all true spiritual growth proceeds.

These interesting specimens—the first two being

typical of exogens, whose growth is from without, and the last of endogens, whose growth is from within—represent the greater part of the family of trees, in the varieties of which there are so many thousands. The screw pine family, from which this latter specimen was taken, affords another opportunity of observing what is called "a law of nature," but which is very strikingly illustrative of Divine wisdom. The foliage is peculiar, its great sword-shaped leaves resembling those of the pine-apple, set with sharp spines along each edge, running in regular spiral turns like a corkscrew, whence the common name of the tribe, *Pandanus spiralis.*

The screw pine is frequently found growing in the loose shallow sands of the coral islands which dot the Pacific Ocean; and, as they are inclined to be "top-heavy," they have "acquired" a very demonstrative method of attaching themselves to the loose soil in which they grow, so as to enable them to resist the force of the furious winds that beat upon them. When the leaves are abundant, and the tree would fall by reason of their excessive weight, the aërial roots which *would* ordinarily have grown straight downward to the earth, issuing from various parts of the stem, when the tree is full-grown and is overloaded, proceed in a *slanting* direction, and, firmly fixing themselves in the ground, surround the trunk, shoring it up just as a carpenter would a falling tenement.

Some years ago a large tree belonging to the family of screw pines, in the palm-house of the Edinburgh Botanical Garden, had one of its branches injured, and at the point of injury a root appeared long before its time, and thus supported a branch which would otherwise have been cut off.*

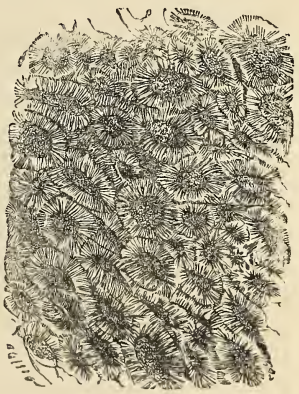
These wood sections will afford us inexpressible

* Professor Balfour.

delight as we ponder over their variety and beauty—whether it be a weakly climber as the clematis, or the sturdy branch or root of the giant old oak; the young branch of the pepper tree, or the slice from a bamboo cane; in each and all we shall be surprised and delighted.

But now, having drawn your attention to these transverse sections of the woody parts of some of our plants, let me ask you to think of their fruits, and of that which, carefully concealed in them, as our souls are in our bodies, we call their seed.

Look at this transverse section of a common cherry-stone. You will see how its hardness is produced in such a soft, fleshy substance, and what security has been afforded to the most important part of the plant, namely, that which is the pledge and assurance of its future life. Separate and distinct cells of singularly beautiful design and solidity, more resembling a multitude of microscopical sunflowers than anything else, protect the germ within. How shall it escape from the hard walls of its prison?



Transverse section of cherry-stone.

When the present London Bridge was built in 1831, pedestals of granite surmounting the piers on the northern side of the river were erected; they are there now, and will doubtless remain for many future years. One day I observed a small tree growing upon one of them. I watched that tree from week to week with great interest, almost as much as poor Piccioli did the little flower in his Italian prison.

I had a special regard for that little adventurer, which had found a solitary home on the stone belonging to the strata which forms, as we presume, the framework of our world. But how could it have found a dwelling-place in such an unlikely place as granite?

Let me tell you.

The masses of primary rock placed on the top of these steps down to the stream were put as near to each other as the mason could get them, but, nevertheless, there was just one little interstice where they met. In that gap there chanced to be room enough for dirt and soot and dust to collect, and one day some passer-by, eating cherries, thoughtlessly threw one of the stones on to the top of these granite masses, and it happened to lodge in one of these insignificant openings. Soon after, down came the rain, moistening the little accumulation of dirt and soot, and the germ of the plant, directly finding one of the necessary elements for its release at hand, began to swell out in its increasing moisture till the walls of its prison gave way, when there appeared two little roots, which directly struck for the dirt and dust below, anchoring the embryo to the accumulation, small though it was. Soon after, up sprang two tiny leaves, and, working steadily day by day, at last a very little branch was formed, and at length the young tree, which attracted both my attention and admiration, appeared. One day, on going to hear what my pet cherry tree had to say to me—for you must know I *do* love to listen to the sweet voice of what we call "nature;" for to me "the voice," not "of the people," but the voice of "nature" *is* "the voice of God;" for does not His own Word say, "Speak to the earth, and it shall teach thee"?* and has not that Word been my precious guide-

* Job xii. 8.

book all along the path of life from boyhood to old age? and have I not imprinted on its sacred covers, "*Title-deeds*"*?*—one day, I say, on going to hear what my pet cherry tree had to say to me, imagine my regret at finding it gone!

Being on friendly terms with the authorities of Fishmongers' Hall, by the front of which my pet had been thriving, I asked if they knew what had become of it, when, to my astonishment, I found it had been pulled up to prevent the roots splitting the granite upon which it grew.

Then came the voice from that dead cherry tree, a root out of a very dry ground, saying—

"How little I really needed for my daily wants! I longed for liberty, and by patient continuance in well-doing I found it. I have finished the work I came to do; for I have given you an illustration of contentedness under the hardest of circumstances, and I have taught you the lesson—under the greatest of trials, to look upwards for the supply of all your necessities, which is sure to come if you will but continue looking.

"Learn from my little life the truth of the saying that

'Incessant pains the end obtains.'

Without aid from above I could not have grown, had I tried ever so hard; but the shower came, and then, like the true 'Plant of renown,' I grew; and you have seen in me an illustration of those greatest of all mysteries, life and growth, and what an almost supernatural power belongs to each. Had I continued undisturbed, the strongest of rocks would have given way under my invisible roots.

"You have received a nature-lesson from me, and more than one, showing chiefly that, as Nature keeps the

secrets of life and growth in her own hands, so no means that your philosophy can discover will ever successfully analyze the mystery of either physical or spiritual life and growth—it all lies in the blessing which is from heaven."

But this story of mine, illustrating, as it clearly does, "the power of the resurrection," * is surpassed by another sent me while writing these pages, and I give it here for the reader's serious consideration.

"A young German countess, who lived about a hundred years ago, was a noted unbeliever, and especially opposed to the doctrine of the resurrection. She died when about thirty years of age, and, before her death, gave orders that her grave should be covered with a solid slab of granite; that around it should be placed square blocks of stone; and that the corners should be fastened to each other and to the granite slab by heavy iron clamps.

"Upon the covering this inscription was placed, 'This burial-place, purchased to all eternity, must never be opened.'

"All that human power could do to prevent any change in that grave was done; but a little seed sprouted, next a little shoot found its way between the side-stone and the upper slab, and it grew there, slowly but steadily forcing its way, until the iron clamps were torn asunder, and the granite lid was raised and is now resting upon the trunk of the tree, which is large and flourishing.

"The people of Hanover regard it with an almost superstitious fear, and speak in lowest tones of the wicked countess: and it is natural they should; for as I stood beside that grave in the old churchyard, it certainly impressed me more deeply than I can express."

Does it not occur to any ordinary mind that, if there

* See Phil. iii. 10.

be such extraordinary "power" given to a plant in its transition from a little seed to a great tree, so that it could burst open a tomb secured with hard stone and iron, like power shall be given to that which, sown a "natural body," shall be raised a "spiritual body"?

Ah! say not that I am preaching a sermon upon trees, but not describing our objects. Our story is about the microscope and its lessons, and by the law of association this remembrance of the London Bridge cherry tree, although above half a century old, came to my mind while examining the beautiful structure of the stone.

But, indeed, if *I have* moralized a little, I have been in good company. My botanical teacher, Dr. Balfour, Professor of Botany and Medicine in the Edinburgh University, does not think it beneath him to draw a moral from trees, nor even to see in their peaceful lives an allegory of something more; and as *he* does not think it inappropriate to his studies, why should I?

Let me, therefore, conclude our botanical study with a few of his remarks on the striking analogies which a devout mind can discover in the vegetable kingdom.

He is writing about fruit. "From all that has been said about fruit," he says, "many important lessons may be drawn. Thus, man in his natural state brings no fruit to perfection (Luke viii. 14); it is, like the crab-apple, unfit for the Master's use. Hosea, in speaking of Israel's attempts to exhibit fruit, says, 'Israel is an empty vine; he bringeth forth fruit unto himself' (x. 1). It is only when grafted by the great Husbandman into the true Vine (John xv. 1), and into the oil-bearing Olive (Rom. xi. 24), that man can bring forth good fruit, even unto life eternal (John iv. 36). Our blessed Lord says to His disciples, 'As the branch cannot bear fruit of itself, except it abide in the vine; no more can ye, except ye abide in Me. I am

the Vine, ye are the branches: he that abideth in Me, and I in him, the same bringeth forth much fruit: for without Me ye can do nothing' (John xv. 4, 5). As the graft is kept in union with the stock by means of the clay which has been applied by the gardener, so is the believer united to Christ by faith, which is the gift of God. The clay-cement keeps the parts together, but has no virtue in itself; so faith is the means of union to Christ—it shows that the Husbandman has been there. The believer has no merit in this; faith cannot save him (Jas. ii. 14) or make him bring forth fruit. It is the union with the Stock which does this. Thus it is that his faith is not dead, being alone (Jas. ii. 17); there is a real, vital engrafting, and faith is seen by the works which are its fruits. By the process of spiritual grafting, he is, so to speak, checked in his own growth, in his self-love, his self-righteousness, and all his sap comes from Christ. In Him are all his well-springs, and from Him alone he derives all the nourishment and support he needs. Thus it is that he flourishes and brings forth the fruit of the Spirit, containing its nine ingredients, 'love, joy, peace, long-suffering, gentleness, goodness, faith, meekness, temperance' (Gal. v. 22, 23), every one of which is necessary to form the perfect fruit. Some of these ingredients may abound more than others, as it were, imparting a peculiar flavour; but all must be there in greater or less quantity. Love may be looked upon as the substance coming from the Stock which unites the graft to it. This flows from Christ to the grafted believer. 'As the Father hath loved Me, so have I loved you: continue ye in My love' (John xv. 9). Thus the union is formed, and he becomes identified with the Stock. This love will last through eternity. When the clay is removed in the case of an ordinary tree, the graft is found

united to the stock; so when faith is swallowed up in sight, then the perfect union of Christ and His people will be seen. Heaven is not to begin, but only to perfect, the living intercourse of believers with Christ and with each other. While on earth they were all grafted into one Stock. They were all one in Christ, who has said, 'Neither pray I for these alone, but for them also which shall believe on Me through their word; that they all may be one; as Thou, Father, art in Me, and I in Thee, that they also may be one in us: that the world may believe that Thou hast sent Me' (John xvii. 20, 21).

"As the fruit may make a great show, but contain no seed with the embryo spark of life, and thus fail in fulfilling the object for which it is formed; so there may be an appearance of spiritual fruit without the vitality of religion. Such fruit, though fair externally, is in reality dead, and fails in the hour of trial. Like seedless fruits, this mock spiritual state may be produced by human cultivation, by an artificial nourishment, by a fostering of self-righteousness. There has been no true grafting, no implanting of the heavenly life in the soul. While, however, seedless fruits are said to be sometimes naturally produced by old trees, this is not the case with the true Christian; for he continues to bear true fruits even in old age, being full of sap (Ps. xcii. 14), derived from the one Source of all fruitfulness, in whom it has pleased the Father that all fulness should dwell (Col. i. 19)." *

This is *my* faith; and such are among the parables of nature which satisfy the wants of *my* spiritual appetite. Is it yours also?

* "Phyto-Theology," pp. 167–170.]

CHAPTER VII.

GEOLOGICAL.

"The whole of creation in this world, and in all worlds, can be but a series of glorious steps, fit for angels themselves to use, as symbolized in Jacob's dream; a ladder from earth to heaven, by which, not in dreams only, but in sober waking certainty, we may hold communion with heavenly realities."—CHEEVER.

NOW, if I have not tired you with my views of what the microscope may lead us to in our "lessons," let me introduce you to some of the many choice specimens in our cabinets which are marked "*Geological.*" There are many interesting sections representing the earth's surface and contents, from the great strata of chalk to the interior of a volcano; nay, right down to the old red sandstone, a depth of twenty-two thousand feet—that is, upwards of four miles, *below* the earth's surface. And then, if you will, we may learn something of the material of the highest mountains in the world, the Himalaya, and discover what appears at a height of twenty-eight thousand feet *above* the surface of the earth.

Where shall we begin? Let it be with the latter.

We live in days when the authority of the Bible is

assailed by scientific would-be giants, who will only believe just what they can see and understand. One has very recently combated the truth of the Noachian deluge, and another, whose weapon of defence is made of better metal, has defended it, proving that nearly every nation has, more or less, some account of that catastrophe: what now does Nature, when called in as a witness, say to it?

This section of the Himalaya mountains shows a solid mass of corals: these persevering little creatures built up their dwellings from the bottom of the deep seas—how, then, came they on the Himalayan heights, far above the level of the nearest sea?

The same question may be asked of the fossils composing the great chalk strata in our own and other lands, one ounce weight of which, you have heard, is said to contain four millions of animal remains; that is, the average weight, *when fossilized*, would be the four-millionth part of an ounce each! These minute but beautiful forms, after passing their ancient lives in pre-Adamite seas, and being transformed into solid bodies by the infiltration of minute particles of lime, were upheaved by subterranean forces, making such masses as we have all along our south coast; and by subterranean heat have again been transformed into masses that have afforded material for the most magnificent of temples and those unequalled sculptures which have come to us from the ruins of Greece and Rome, in white marble.

Section of chalk, with fossils *in situ*.

These wonderfully beautiful creatures are among the first forms of life, and to them we owe the vast extent of chalk which is found in such abundance; and, by the accumulations of ages, these little microscopical bodies at the sea bottom may form the chalk of a new world when the present age and dispensation shall have passed away. Corals, sponges, and Foraminifera—of such are the rocks of the old world formed. When you look into the objects before you, you will find the minute shells of the latter all pierced with a number of little holes, through which the tiny thing would protrude its minute hairy feelers for the capture of its food, or for instruments of locomotion through the water.

Says one writer, "In the organically formed rocks, they have, it may be said, taken the lead, and done far more than any other living being. To the formation of the chalk rocks of the world, they have, by their shells, contributed about ninety per cent. of the whole mass." And to such minute creatures as these, though not of the same family, do we owe the material with which the houses in many of our largest cities are built.

Section of limestone, frequently used for building purposes.

The Pyramids of Egypt were once all alive, for they are entirely composed of minute fossil animals. The greater portion of the stone of which Paris is built is formed of similar bodies; and in one cubic inch of the Bohemian rock, from which is obtained the common article of trade known as Tripoli, or polishing powder, it is estimated 40,000

millions of such once-living bodies have been reckoned. How hard such stone becomes, and how durable, you may believe when I tell you that the paving-stones of the London Royal Exchange, where "merchants most do congregate," and which were laid there when the first building was erected in the reign of Queen Elizabeth—that is, three hundred years ago,—are there still, though trodden by the millions of feet of men who have long since gone to their account.

Now, while I show you some of the best specimens I have seen of these Foraminifera in their natural, that is their now fossiliferous form, let me tell you how they came into my possession.

My good friend, Mr. E. H. Robertson, to whom I am indebted for many interesting facts connected with this subject, begged me to get him a quantity of that fine sand which the importers of sponge beat out of the specimens before they are offered for sale.

When the sponge of commerce, which is really the skeleton of an animal from which the fleshy part has passed away, was living, it was of a soft gelatinous nature. The openings which you see in an ordinary mass, such as that used for washing purposes, are the mouths, if we may so call them, of the living sponge, through which the life-giving air passes into the animal, and through which is carried the small portions of animal matter on which sponges feed.

Now, these little Foraminifera (so called from the two Latin words—*foramen*, an opening, and *fero*, I bear) evidently were to the living sponge just what swallowing power is to a living man; and everybody knows what the result would be were he to attempt to swallow an oyster, shell and all. That is precisely the result in the case of the sponge. The minute shells of the Fora-

minifera become embedded in the network of the sponge, and there they remain, as the grain of sand does which forms the nucleus of the pearl which is found in the shell of the oyster. And thus, with myriads of grains of sand

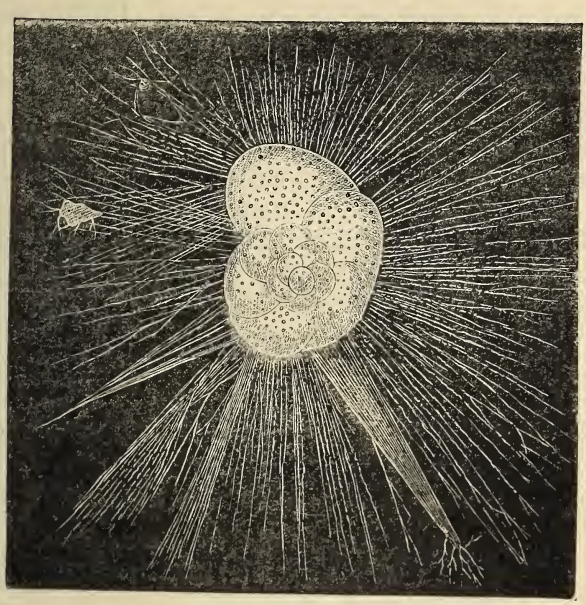
Foramin'fera, from the sponge of commerce.

which likewise find an entrance, with the water, into the body of the sponge, sand and foraminifera become commingled.

My friend already referred to says, "I recently prepared about thirty pounds of 'sponge-sand,' obtaining, as

the fruit of my patient labour, about—'*Two or three pounds of Foraminifera!*' perhaps some eager microscopist will exclaim. Nay, not so; but about a piled-up teaspoonful of exquisite shells." *

He has kindly allowed me to use a cast of the cut with which he has illustrated his subject, and which was



Foraminifer, with extended pseudopodia.

drawn from the object itself, being his own preparation; and the reader will gather from the few but varied forms it contains a faint idea of their diversity and beauty.

I do not wonder at his enthusiasm over his favourite

* From an admirable article, "Gossip about Foraminifera," by E. H. Robertson, in *Science Gossip*, July 1, 1889.

subject; nor will you, while you listen to his story as you look at some of his very excellent preparations.

"Marvel of marvels," says he, "in this world of wonders, that a globule of jelly destitute of any external integument should put forth such attenuated filaments"—that is, the hair-like processes which are seen piercing through the invisible openings which give the name to these specks of creation,—"the atoms of which not only cohere, but serve the double office of organs of locomotion, and of cables mooring it to its anchorage! Yet so it is; and the factor in this wonder is that mystery of mysteries—that principle which we call life, the secret of which we are ever seeking to penetrate, but which we, living in an age of electricity and steam, seem as far off from doing as were the sages who, a hundred generations past, strove to fathom its profound depths.

"Unendowed with the complex organizations of animals higher in the scale than themselves, these tiny things of beauty yet perform the varied functions of life efficiently, exercising a most important influence in Nature's economy. . . .

"Whole ranges of mountains, in various parts of the world, are composed of these tiny creatures, and vast deposits of them, spreading in the aggregate over many thousands of square miles, have been traced in Hindostan, Egypt, and the Holy Land and Arabia. These minute organisms constitute the mass of that pure white substance which has given—so it is said—its name of Albion (*alba*, white) to Britain; and how inconceivably vast must be these hosts, when it is remembered that this formation alone once extended in a north-westerly and south-easterly direction from Ireland to the Crimea, a distance of eleven hundred miles; its breadth, from the south of Sweden to the south of Bordeaux, being (allow-

ing for breaks caused by denudation) about 840 miles; its thickness in this country averaging from six hundred to eight hundred feet."

"If all the points at which true chalk occurs," says Professor Huxley, "were circumscribed, they would be within an irregular oval of about three thousand miles in long diameter—the area of which would be as great as that of Europe."

You will observe in our specimens how nearly some of these forms resemble the nautilus and the ammonite, which in prehistoric ages lived harmoniously together, before there was a man to look into their secrets with a microscope, as we are at present doing; now the ammonite is extinct, and found only among the fossils.

Thus you may see of what our ordinary building-stone is formed. A bit of our church wall, which a few years ago was erected, and a small chip of which I had prepared for my cabinet, is a mass of corals. This stone is called "Kentish rag." Here is another bit, from the remains of the old Roman wall which was recently discovered in digging for the foundation of a house in Houndsditch, and which I went to inspect. There it had been lying for about two thousand years. It is a mass of marine animal remains.

"Where is the dust that has not been alive?"

And here is a chip from the Great Pyramid of Egypt, that wonder of the world which, nobody knows how many thousands of years ago, was erected, according to tradition, by one hundred thousand men in twenty years. Six millions of tons of stone is said to have been employed in its construction, making it the most stupendous mass of masonry in the world, its top reaching considerably beyond the cross of the London cathedral church of St. Paul's. It is a solid mass, you see, of animals called

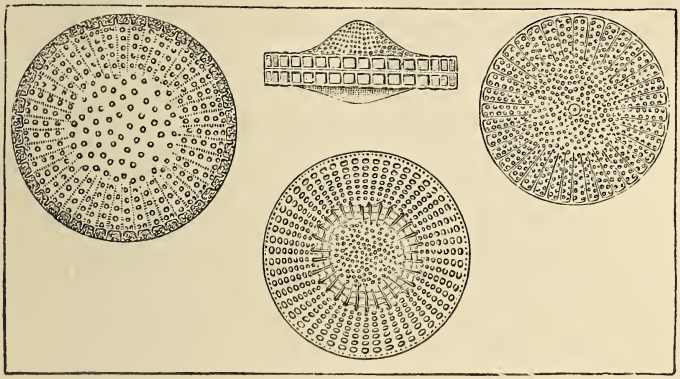
nummulites, considerably larger than our Foraminiferous object, but not half so beautiful. And here, allied to this curiosity, is another small piece from the Vocal Memnon of Thebes, that huge record of the mighty past, an obelisk called the Sphinx, probably a column forming the entrance to some grand temple when Moses was brought up in the Court of Pharaoh; but how different to its near neighbour! This great figure has very recently been discovered to be considerably larger than any history has recorded; the sculptor fashioned a fabulous being, the human part being represented by a female. This "Vocal Sphinx" was so called because it was said to sing when the sun arose, and to sigh when it set. The structure of the stone, when viewed as an opaque object—that is, by transmitted light—gives it all the appearance of the human lung, being formed of a material entirely different to limestone; but which, from its porous character, may give some day a modern clue to the mystery of its ancient music.

From chalk we naturally pass to flint, which we find to be so frequently embedded in it. Think of the various forms which this flint takes, from the beautiful spicules in sponge, to those of the still more beautiful siliceous skeletons of some of the lowest forms of vegetable life which we have already seen in Diatomaceæ! The beautiful forms of the Foraminifera are even surpassed in these exquisite gems of nature, and their size is infinitely smaller; the markings often resembling the fine engine-turned lines of a watch-case, though almost immeasurably finer.

Here are four beautiful species of these minute skeletons, magnified four hundred *diameters;* but as this work was not intended for experts in microscopical knowledge, but beginners, I may here remark that their true

superficial measurement, that is, their entirety, as now presented to your eye, is one hundred and sixty thousand times larger than they *really* are. I mention this "*superficial measurement*" here as I have done elsewhere in the book, that you may try to realize what is meant by "the invisible world," for without the microscope they could never have been discovered.

These four "*frustules*," as they are called, are all fossil, and appear to be flat discs, but they are slightly convex, and consist of two valves, united by their outer



Fossil Diatomaceæ.

edges; the top middle figure represents the two valves thus united, forming a sort of case in which all the vital processes of their little lives are performed.

Having already shown you the exquisite siliceous skeletons of such plants as the deutzia, I need do no more than remind you of the marvellous way in which this element is diffused throughout the vegetable kingdom, and that just as our own bony skeletons are formed of lime, the base of which is chalk, so the whole vegetable world is indebted to flint for the framework of that

wonder of wonders we call a leaf, and sometimes enclose in a letter to one whom we love, and with it write—

> *Only a leaf*, yet it shall bear
> A wealth of love, of mintage true;
> Only a simple earnest prayer,
> That silently goes up for you;
> Yet you and I may never know
> What blessings from that prayer may flow."

Do we say this because a *leaf* comes from a tree, and the word "*tree*" comes to us from the same etymological root as "*true*"? Is a leaf the hieroglyphic of truth?

Flint.—Here is a very thinly cut section of a pebble from the Norwich drift; it is a mass of fossil remains of animals and plants, the relics of the immeasurable past, one of the many medals of the earliest days of the creation of our world; it is a striking illustration of the truth of the words of Professor Owen, who once said that every bit of coal had moved as sap in the vessels of a plant, and each cliff and quarry of chalk and limestone and marble once circulated in the vascular tissue of an animal.*

And here are various specimens of coprolites from different districts in England. The word divided signifies "*stone*" and "*dung*,"—you would take the *stone*, of which this section is a very thin slice, to have been a common pebble such as you would have met with by the roadside. Look at it, first with a low power; then, as you always should, increase it, and you will see that which, even with your previous aid, was invisible.

Let me explain to you, in a child's language, what this section really is.

* "Exeter Hall Lectures," 1863-4.

You can easily understand that, were your body now suddenly turned into stone, a part of the last meal of which you were a partaker would become a fossil: and don't forget that the word "fossil" means "dug" (Latin, *fossus*), and that it refers always to the remains of plants or animals dug out of the earth's crust, changed into a stony subtance. Now, were your body so transformed, a portion of your undigested food would be found—a stony conglomerate—inside some part of the thirty feet of that intestinal canal of yours, would it not? Now, that is exactly what this is. In Cambridgeshire there are vast beds of this stone found, called "coprolites." Once upon a time, in that county, long before its splendid colleges were built or any student or any human being was to be seen there, in the dim misty ages of the past—most likely millions of years ago,—this county was inhabited chiefly by that large tribe of reptiles to which the crocodile and shark belong: they "lived and died and were buried," as the newspapers have said of a very rich man, perhaps all they *could* say without saying much that was worse,—these reptiles lived and died and were buried; that is, their bodies sank in the element in which they lived, and absorbed the earthy matter which received them, and which formed their graves; and, gradually, they became fossilized, and remained for us of the nineteenth century to "dig" out of their long, very long, hiding-place.

You may guess the character of these living beings in the early records of the life of our little world from the object before you, and you will be surprised when I tell you that, in this county of Cambridgeshire alone, so much as a million and a half of sterling money of our country was recently paid for coprolites per annum, which, at the then current value of sixty shillings a ton, would be equal to from 400 to 500 thousand tons. These Cambridgeshire

masses of stone dung are found in beds about ten feet below the earth's surface, which yield out of every twenty pounds about three of coprolite—that is, about thirteen per cent. And here, in the same geological division of our little world of wonders—our cabinet of 750 microscopical objects,—we have the fossil teeth of reptiles, sharks especially, from the same beds, showing to what families these pre-Adamite brutes belonged, in which the ivory and dentine are in such excellent preservation that a well-prepared specimen, cut exceedingly thin, will show us more of the structure of the teeth than would one taken from the mouth of a recently dead animal. Nay more, in the fossil tooth of an ichthyosaurus of our cabinet we have not only the original tooth, but, that decaying, we may behold the new tooth arising in the socket, ready to take its place when the decay is complete;* and all, in the course of ages, silently but so perfectly absorbing the minerals, then in a state of semi-solution, that ages after, when dug out of their graves, the ivory cells are as clear to the eye, with the aid of the microscope, as daylight. But we have not yet done with our slice of coprolite. Yes, they *are* "bones," the broken pieces of which you noticed in the half-digested mass of partly excrementitious matter. You said rightly; but observe, they are fish-bones, and they show that in whatever body they were devoured as food, that body must have been aquatic. But let us now employ our higher power, and then we shall see the structure of the fish-bone which formed part of the skeleton of the smaller animal and which afterwards became food for the larger; and not the structure only, but the vessels which supplied the structure itself with food, namely the blood.

* This valuable specimen was obtained from a portion of jawbone of ichthyosaurus from Lyme Regis, Dorsetshire.

Cup sponge, *in situ*; half natural size.

Vessels!—Can anything be *truly* said to be "lost," after this?

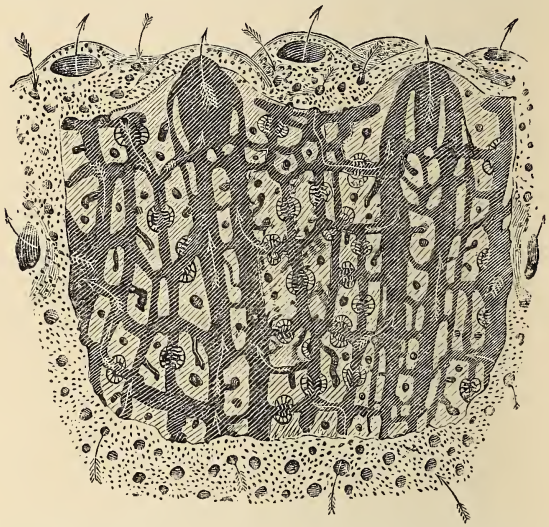
One of my friends once showed me the ball from the socket of one of the mighty limbs of the gigantic mastodon, one of those prehistoric animals which, ages since, inhabited our dear England long before the advent of our Druid or Saxon ancestors. It was found in the Thames, and was supposed to have fallen in while the embankment at Westminster was making; it measured thirty-eight inches in circumference, and weighed forty-one pounds.

These interesting remains of an antediluvian epoch, which have been discovered from time to time in and near London, have received an addition in the fossilized bones of a whale in my own immediate neighbourhood, at Greenwich, while they were excavating for the railway there. The remains, which consisted of part of the vertebræ and jawbone, were lying in the gravel, and were in a fair state of preservation.

Having directed your thoughts to similar objects, connected more or less with microscopical studies, in previous works, I must not occupy either time or space in repetition; but I would here call your attention, very briefly, to the great family of sponges, both recent and fossil, for you will find that in the latter state, both in their vertical and horizontal sections (several beautifully prepared specimens of which await our examination), that the skeleton is seen perfectly—much more so, indeed, than in a living sponge—but entirely filled up with silica, which being transparent when cut down to a minimum of thinness, the network of the skeleton is clearly seen through.

We must not suppose that these phenomena are confined either to the surface of our earth or to our own

planet. I may remind you, while the subject of foraminifera, corals, and sponges—which, remember, are among the first known forms of animal life upon our earth—is fresh upon your mind, that only a few years ago it was reported from Berlin that a Dr. O. Hahn had discovered, with the aid of his microscope, the presence of organic remains in the stones which dart into the

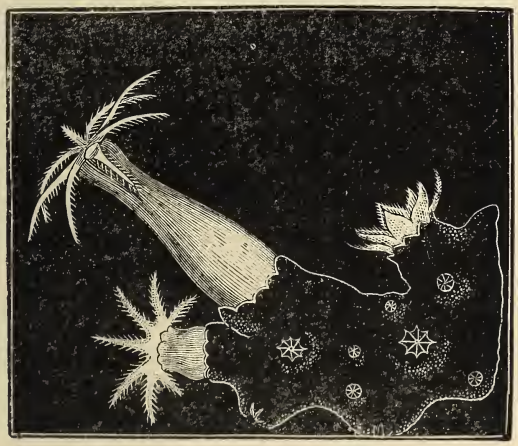


Interior of sponge channels. The arrows indicate the direction of the current.

terrestrial atmosphere from stellar space. From museums in Tübingen and in Vienna, he procured more than six hundred chips of meteorites of the choanite class, discovering in them a quantity of organic remains, principally belonging to the most ancient form of porous corallines, the genus of fossil zoophytes denominated Favosites. Dr. Hahn discovered about fifty kinds of

these tiny animals, and assigned them to sixteen different families, to which he has given names, thus laying the foundation of a new branch of zoology—meteoric geology.

When we consider the height from which these masses fell—their contents, and the thoughts which they suggest, and think also of the fossil contents of the mountains of our own world;—when we dig into the earth and see the masses of dead matter there deposited, which supply us with the enormous quantity of artificial manure, all



Enlarged polypes of the red coral, with extended tentacles.

foreseen and forethought of, that there might be nourishment for man and beast while the present dispensation lasts; and again, when from such thoughts our attention is directed to the deepest sea-soundings such as were taken on board the *Challenger* in 1876, and what is disclosed at the deepest ascertained measurement of the ocean,—we are lost and bewildered in amazement, and know not what to think, as our brain nearly reels in our study.

In that interesting voyage of the *Challenger*, the contents of many boxes of ooze were brought up from soundings ranging from 50 to 4750 fathoms—for that almost incredible depth was reached as the ship was crossing from Japan to the Society Islands in the Pacific.

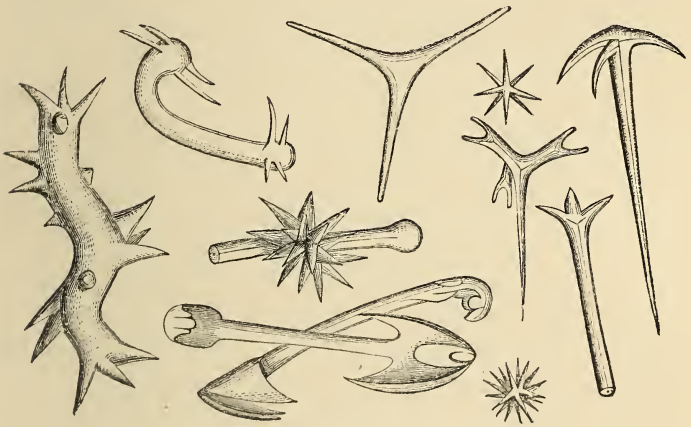
A fathom is equal to six feet, and there are 5280 feet in a mile, so the greatest ocean-depth that has yet been known to have been reached is very nearly five miles and a half; and what does it reveal?

Look! the diameter of the little circle on our object now before you is only half an inch, and yet in that small space there may be thousands of the most lovely forms, from the spicules of sponges to those exquisite Polycystina which astonish and delight all who have eyes to see; and there, again, is that marvellous medal of creation, not larger than the point of an ordinary-sized pin in its circumference, the disc, called, after its spider-web-like pattern, the Arachnoidiscus.

"The works of the Lord are great, sought out of all them that have pleasure therein;" and what does *our* "searching" among these lovely inhabitants of the deepest of seas, invisible as they are to our unaided eyes, tell us? That flint and chalk are the two chief mineral ingredients which God has employed in the composition of ocean-depths and mountain-heights; for, observe, Foraminifera, sponge spicules, Polycystina, and Diatomaceæ are found in a recent, as, forming solid masses, they are discovered in a fossil state.

These infinitely little creatures, whose bodies, many years after they ceased to live, became fossilized by an infiltration of lime, thus changed to what we know as "chalk," still preserving their beauty of form, each taking its part in the formation of huge sub-aqueous masses, which, afterwards, by mighty subterranean forces

were upheaved into mountains, thus producing the beautiful unevenness of the earth's surface; whilst the flinty skeletons preserved their original loveliness, and, as we see in the deep-sea soundings, on comparing fossil with recent specimens, both are found entire: so that we may reasonably believe that the bed of the deepest seas is gradually being prepared, by the accumulation of infinitely little animal remains, for the mountains of a future age.



Various forms of sponge spicules.

The old painters, before commencing their work, knelt before the blank canvas, and asked God's blessing on the work they were about to commence. Should we not, in like manner, approach the study which has brought us together with a reverential and adoring spirit, while we behold the Almightiness of God, as distinctly visible in an atom as in the creation of a world?

Before leaving this very interesting part of our study, do let me again direct your attention to the variety of forms in these sponge spicules, all of which, remember,

are composed of flint. They are to the sponge what the earthy deposit in the bony structure is to more perfect animals, and they are amongst the earliest developed of the organs of the sponge. They are the instruments of defence as well as the organs of prehension; and what a formidable array of daggers, lances, spears, and harpoons do they present! Woe be to the tiny mite that comes too near these flinty weapons of attack and defence!

Do you see how God has provided this humble creature, a soft gelatinous mass only of living matter, with the most effectual means of self-protection? Then, too, as between the larger spicula the smaller tribes of animals so abundant in the sea would readily insinuate themselves, there is frequently a secondary series of defensive weapons—all formed, mind, of flint,—a perfect armoury, of short, finer-pointed spikes, thus rendering the progress of the smaller enemies extremely difficult, if not impossible.

Anchors and plates of Synapta, detached. Drawn from nature.

Now just look at *this:* it is the weapon of defence as well as the organ of protection, used by a kind of marine slug in the same manner as we of the upper class use our hands. This humble denizen of the seas is provided with the most wonderful coat of armour that has ever been seen. The *Synapta*, from which these spines were taken, is furnished with numerous anchor-shaped weapons, which articulate in a beautifully

sculptured flinty plate beneath. When irritated or excited, just as a body of infantry kneel to receive a charge of cavalry with fixed bayonets, or a hedgehog to receive a dog, or a porcupine to defend itself from an enemy; so, over the whole surface of the body of a synapta, these sharp-pointed flukes of the anchor-shaped spines are made to project, upon the extremities of which the adversary becomes impaled.

Who would have thought that the mineral with which we are so familiar, and which, in the form of a pebble, we so often thoughtlessly kick on the roadside, or shovel up in minute atoms on the sea-shore in the form of sand, could, by the slow process of nature, be wrought into such lovely forms as those we see in the skeletons of plants or the spicules of a sponge?

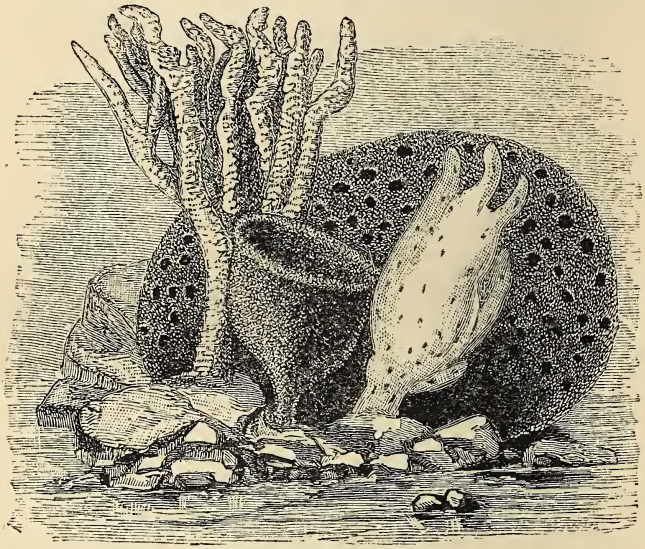
Sometimes the thickness of a sponge may not be more than the paper which forms the page upon which this is printed, and yet there is room and to spare for these siliceous armouries, in which a small worm, entangled amidst such deadly instruments, would struggle in vain.

It may be, and I believe is, that the anchor-shaped spines of the synapta are intended for such a purpose, serving, not only for prehension, but protection. Here is a specimen in which the flukes of the anchor are serrated, thus giving it a firmer hold. Some years ago I was showing these spines to a mechanical friend, who had taken out a patent for a new anchor, and when he saw the object now under our glass he angrily exclaimed, "Why, somebody has infringed my patent, and has actually copied my design!"

Now, when you use your sponge, will you think of the romantic story this curious family could tell, both in the long dim ages of the past, and in the more lively chapters

of the present, had it the power of speech? "Family," you say; "then, are there many varieties?" Very many, and their forms are as different as their numbers are great; while their fossil remains, strikingly visible in many common pebbles, are deeply interesting to the "pebble-seeker."

We are told that something like five hundred tons of



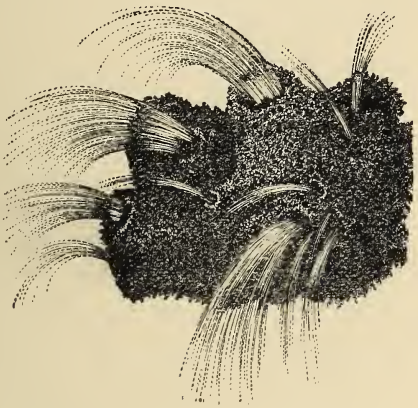
A group of sponges.

sponges—worth more than £170,000—are annually sold in England alone; the horny skeleton of very lowly organization having around it in its ordinary life a fleshly mass of slimy "sarcode," which, before the mass can be fit for the dealer, must be stripped off.

Since sponges have risen so enormously in price, attempts have been made to cultivate them artificially by growing them from cuttings. A farm of this sort was

actually carried on in the Adriatic, and for six years promised to be successful; but the plan was defeated by rival dealers, who imagined that this invention boded evil to their craft.

Have I wearied you in the brief study of so very humble a creature as a sponge? And do you think much of the evidence of the care that God has taken over one of the weakest of His creatures? and do you not conclude that, therefore, much more will He care for you? And



Expulsion of water by a living sponge.

will you not join in David's prayer, and devoutly say, "O Lord, how wonderful are Thy works! in wisdom hast Thou made them all; the earth is full of Thy riches: so is this great and wide sea, wherein are things creeping innumerable, both small and great beasts"? And, lastly, are you ready to believe in the fact that amidst the "*all*," —that is, from the smallest atom of creation which the strongest magnifying power almost fails exactly to discern, namely, a monad, and the largest moving animal, that is the whale,—the half-way house is our little

friend, the house-fly: that is, that there may be as many creations from the monad to the fly as there are from the fly to the whale? And do you not see that *this* points to another thought, belonging to another and a higher life, and the grand possibilities which await us?

CHAPTER VIII.

ANATOMICAL.

"And God said, Let us make man in our image, after our likeness. . . . So God created man in His own image, in the image of God created He him."—GEN. i. 26, 27.

"We are the offspring of God."—ACTS xiii. 29.

"What a piece of work is man! How noble in reason! how infinite in faculty! in form and moving, how express and admirable! in action how like an angel! in apprehension, how like a god!"—SHAKESPEARE.

OUR microscopical studies would be incomplete without some reference to what should interest us more than anything else; I mean, ourselves. We have already seen something of the wonders of the world we live *on;* shall we not look into some of the wonders of the world we live *in?* Awaiting our patient investigation, are preparations of the human body from the crown of the head to the sole of the foot, externally and internally, from the brain down to the lungs, the heart, and the stomach.

There are some who are afraid to know of the mysteries which are associated with their lives, but surely this is unwise. We are reminded that "we are fearfully and wonderfully made;" but how can we appreciate the wonder of a thing the mechanism of which

we are content to remain in ignorance of; and, still less, how can we love One whom we do not know?

"The proper study of mankind is man;" and he who would know something of the greatest mystery of all mysteries, the mystery of life, must enter into the elaborate workshop where it is hidden, and though of the *cause* he will remain in greater ignorance than ever, since none but He who first breathed into the body the breath of *lives* can fully comprehend what life really is, still he will, or he should, find the contemplation of the marvels of the bodily house he lives in a great incentive to further knowledge, and a sure aid to the increase of devotion.

So let us begin with the very beginning of human life; and, that we may not err in our entrance, let me direct you to one of my favourite psalms, in which the genesis of our being is curiously but exactly, and, as we shall presently see with our own eyes, also perfectly and wonderfully described.

In that inspired poem, the 139th Psalm, the author writes, "My substance was not hid from Thee, when I was made in secret, and curiously wrought in the lowest parts of the earth. Thine eyes did see my substance, yet being unperfect; and in Thy book all my members were written, which in continuance were fashioned, when as yet there was none of them." And these words, you must remember, immediately follow what led to them, and that is *praise:* "I will praise Thee; for I am fearfully and wonderfully made: marvellous are Thy works; and that my soul knoweth right well."

I have attended one church and another, Sunday after Sunday, for nearly threescore years and ten, and I have never once, that I can remember, heard one sermon preached upon these wonderful words, and if I err

in introducing you to a few illustrations proving to you the truth of the divine record in which they are written, it will be in good company, having only the glory of God and your edification for my object.

You will of course conclude, from reading the words, that they very inadequately describe to us what was in the mind of the author when he wrote. Have you ever really and truly pondered over their mysterious meaning? *"Thy look"! "my substance"! "curiously wrought"! "in continuance were fashioned"!* Do you not see they clearly refer to human life before it became an inhabitant of the world, when it had, not only as we have had, the "genesis," but as we shall have, the "exodus"? What was I? what am I? what shall I soon be? these are the three great questions that we should practically consider if we would have a right view of the greatness and grandeur of human life.

"Does not everything around us and within us indicate this life is preliminary and preparatory—only a segment, and not a circle? If we are preparing for something, should we not ask for what? If we are afloat, and the shore moves from us, and farewells are wafted from the banks, shall we not ask whither? From the beginning to the end of the Bible the fact of a spiritual world is assured. No attempt is made to prove it logically, for the simple reason that rents and openings are constantly made, through which it floods the earth with sunshine."

These remarks apply, I know, to man's spiritual life, with which the microscope has nothing to do; but the body is the dwelling-place of the soul, even as the nut is that of the kernel, and while we are studying the mystery of the outer part, we cannot help reflecting upon the grand structure it has to exhibit.

"Curiously wrought"! "in continuance fashioned!"

Look at this. It is the finger of a small infant—a very choice specimen, because it is injected with red fluid, which gives it all the appearance of life. The finger-nail, nicely formed, measures only the one-tenth part of an inch; the skin is so thin that we can see through it, as indeed it is not perfectly and finally formed. What does it look like, and, had I kept you in ignorance of its true nature, what would you have supposed it to have been?

You might say rightly, "Some beautifully fine piece of needlework, worked by some fairy fingers into the most exquisite pattern of tasselwork."

Now, just look at one of your own fingers. All along the top there you will observe a series of lines running round one another, interspersed with microscopical dots equidistant from each other. If you think, you will arrive at the fact that beneath the epidermis—the outer skin, that is—corresponding with these depressions, there would be an equal distribution of elevations; that is just what you are looking at. But, as we have said, these capillary loops, with their fringe-like appearance, appear to resemble the finest of needlework. Now hear what that eminent Hebrew scholar, Dr. Mason Good, says about the fifteenth verse of the Psalm already referred to. He says, "It is better rendered, '*when I was wrought with a needle* in the depths of the earth,' in allusion to the sacerdotal robes of the high priest (see Exod. xxviii. 2). The indescribable texture of the human system" (these are not my words, but his) "is, therefore, with much propriety, compared to the exquisite needlework of the high priest's vestments; 'and thou shalt make holy vestments for Aaron thy brother for glory and beauty.'"

Is this what another famous Hebrew scholar once referred to, I wonder, when he asked these words?—"What!

know ye not that your body is the temple of the Holy Ghost which is in you?" *

As the tabernacle was formed according to the pattern showed to Moses in the Mount,† and as the temple afterwards was formed after the pattern of the tabernacle, but expanded, and, like it, consisted of three parts, wherein were, first, the outer court, in which a mixed multitude might congregate; secondly, that part where sacrifices were made; and, thirdly, the holy place into which the high priest alone was allowed to enter;—so, after a similar pattern, is the human body built up. Such is our knowledge of its wonderful nature. We know much about the outer structure of bone and muscle, and nerve and sinew; we know much, too, of intelligence and the structure and function of brain; but of the cause of life itself we are, and always shall be, in profound ignorance—that is, the inmost sanctuary, and only He knows who is its Author. Yes, your body and mine is fashioned after the similitude of the tabernacle, and so He who dignified poor human nature by taking the human form said, "Destroy this *temple*, and in three days I will raise it again;" and one whom He loved reminds us that "as He is, so are we *in this world*." Also, in several passages of Scripture, this body, frail as it is, is called God's house.

Life may be, and I often think is, the action of electricity in some incomprehensible form, for think what electricity has been made to do. To repeat sounds, as of an operatic performance produced a year ago, and repeated by an instrument a thousand times; an instrument—the *phonograph* ("sound-graving")—by means of which words spoken by the human voice can be, literally, stored up and reproduced at will over and over again, hundreds, it may be thousands, of times; by means of which the

* 1 Cor. vi. 19. † Heb. viii. 5.

old familiar voice of one who is no longer with us on earth can be heard speaking to us in the very tones and measure to which our ears were once accustomed. And this wonderful instrument, after all, simply consists of a plate of metal, with apparatus capable of striking upon it so as to produce a musical sound, the plate being sent by post to any part of the world, and the message absolutely respoken in the very voice of the sender purely by mechanical agency.

Well said Mrs. Siddons, the celebrated actress, on seeing the Apollo Belvedere in the Louvre at Paris, "How great must be the Being who created the genius which could produce such a form as this!"

Electricity has been, and is now, commonly used to enable us to speak with one at a considerable distance, as in the *telephone,* which now joins London and Paris; and they *do* say that the inventor is busily occupied in the discovery of a method by which electricity will enable us to see what is going on in any part of the world. But then comes the question, *What is electricity?* We get so far, but no further. Is the brain a galvanic battery, and all the nerves so many telegraph-wires, which, all communicating with the great central station at the top of the house we live in, fetch and carry all the messages, even from the furthermost member of the body, forming the means whereby we hold communion with the outer world, and become acquainted, through the senses, with one another, and the glory and beauty of the wonderful globe we live on?

What is life? what is electricity? what *really* is the mystery of being? Who shall tell us? "We are but of yesterday, and know nothing" (Job viii. 9).

Our next illustration is from another object, but of a similar kind to the last. It is the human knee-joint in its

very early formation, being probably only three and a half *months* old. "Ah," you may well say, "how wonderful!"

Here is another reminder of the words already quoted, "which in continuance were fashioned, when as yet there was none of them." There is hardly any part of the bodily house we live in more characteristic of design than the ball-and-socket joint of the knee; if we only knew how much of our happiness depends upon the self-lubrication of this masterpiece of workmanship, we should thank God at every step we take in the path of life.

Carefully enwrapped in a bundle of striated muscle, is the first formation of human bone, and this is the earliest stage of a ball-and-socket joint, and here is the place prepared—or shall we say, "*curiously fashioned*"?—for that precious little knee-pan called the *patella*,* a round flat bone, not joined to the other, but lying very closely upon it, and kept in its place by the tendons just coming into view. There is scarcely any one of the 223 bones of the body but what might be spared as well, if not better, than this, which, though not larger than a crown piece, protects the knee-joint from any injury which might occur by the rubbing of one part against another, and supplies exactly the want which the "keepers of the house" require in the many duties they have daily to perform.

Here, again, is a tiny drop of human blood, containing a number of *corpuscles* ("little bodies"), so laid out that we can not only measure their diameter but count their number, though the latter would be no easy task, since we are told that three millions would all lie in the size of a pin's head (Tyndall); and the measurement, too, would bother some of us, being only $\frac{1}{3500}$ part of an inch. You will see they are all nucleated—that is, having a

* Latin, "a small plate."

central offspring, which will take the place of its parent, with a third generation concealed in *it*, one taking the place of the other when it has accomplished its work. This book does not pretend to approach a treatise on physiology, and so all that is necessary, in thinking of the important part of life which the red corpuscles play in bodily health, is to let you see upon what little things much of our happiness depends. Observe they are flattened discs. I have told you their diameter is only $\frac{1}{3500}$ part of an inch. The circle upon which they are spread on our glass slip measures half an inch in diameter. It is ten times larger in circumference than a pin's head, and three millions of these red blood-discs, remember, will lie in that space.

These blood-discs are very indestructible, and may be extracted from the blood-stains on weapons upon which the blood has remained for many years; hence the value of the microscope in criminal investigation. The scarlet hue is due to iron, and from the dead bodies of their friends, when cremated, our French neighbours sometimes find iron enough to make a mourning-ring.

Every time your heart beats it tolls the knell of twenty millions of these little organisms.* You may naturally ask, How is it possible to measure these infinitely small bodies, or to count such vast numbers?

The same question might fairly have been asked as we looked at the many thousand lenses of the gnat, or those of beetles. It were impossible to measure or to count them, but we have a micrographic measurer, called a *micrometer*, that is, a measurer of little things—a photograph, on which are about a thousand minute divisions, each numbered, and by laying this over the object, and counting or measuring a given number in one division,

* Dr. Lawson, in "Popular Physiology."

and multiplying by the number of divisions covering the mass, we can accurately determine both size and number.

Now we pass on to the most important part of all—that which the wise King of Israel called "the golden bowl" (Eccles. xii. 6), the human brain. Let us suppose we have before us a tolerably large slice, a horizontal section, properly and delicately prepared with red injection, giving it all the appearance of life. It is from the cerebrum, or front, or proper brain, that which constitutes the intelligent part of the medium of mind. It is covered with an extremely fine network of capillaries, which, having taken up the red injection, and which in the living being would have been the channels taking blood-nourishment to every cell of the brain, gives to this deeply interesting object close resemblance to life, motion excepted.

Have you ever thought of that wonderful property which we call *memory?* What is memory? How is it that, every particle of the human body—bone, muscle, skin, nail, and brain—being changed once every four years, now science thinks, but even should it be seven, as it was said to be years ago, a man of seventy years of age has had at least ten different bodies, and lost ten different brains, which certainly have been the instruments employed in recollection,—how is it that he can better remember some of the events which happened during the life of brain number *one* than in brain number *nine?*

Our bodies change repeatedly, so remember that it is literally as well as metaphorically true that we "die daily."

Look at this slice of the human brain. It consists of a countless number of very minute cells. Our magnifying glass, called a "*sixth*," with the strongest eyepiece, called the "D," or fourth, will, with an extended drawtube, give us a power much beyond a million of times, and yet are we far from success in detecting the structure

of these microscopic cells. We found that three millions of blood-discs would lie in the compass of a pin's head, and these brain-cells are very considerably smaller than they. I cannot tell you the cubical contents of a man's brain, but I can give you its weight, and that is about all that can be told with accuracy and beyond dispute. The weight, then, of an adult male European brain varies between three pounds ten ounces and four pounds six ounces; and the grey matter, of which these infinitely small bodies are composed, is connected (in its entirety) with the mental operations; and, as Dr. Lawson says, after describing various operations performed upon the brain, "all these facts point to one and the same conclusion, viz. *that in the cerebrum are located the various faculties of mind.*" But then we come again upon the question, *What is memory?* Are all these countless, and, except by the aid of the strongest glasses, invisible cerebral cells the storehouses of thought? and do they constitute what our Shakespeare calls the "mind's eye"? But, then, think again of the brains some of us have had repeated and rebuilt from new material over and over, perhaps more than ten times. How is it that the mind, which is the source of memory, has not gone with the cerebral cells, the tenant with the dwelling, the seven years' lease having expired? All that echo replies is, "How?"

Clearly enough, the multitude of multitudes of cerebral cells in an average-sized human brain are enough, provided only one event in a long life were stored in each, to record the story of its entire length from infancy to old age; but how the remembrance is retained, year after year, long after these little organisms have passed away, who shall tell? Surely this is one of the very hardest nuts a materialist has to crack!

Our next object is the transverse section of the spinal cord, that main branch of the telegraph system of the body which runs through the entire length of the backbone, the vertebræ.

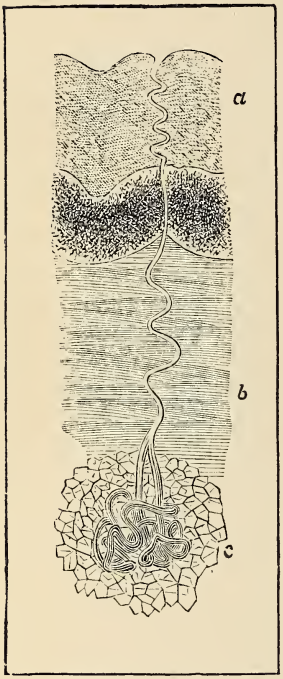
Let us compare this injected specimen with a small piece of a submarine telegraph cable, bearing in mind the idea of the association of life with electricity.

Observe the striking resemblance which one bears to the other. The grey matter of the brain surrounds the central aperture, up which flashes the sense of feeling from the most distant member of the body, the foot, conveying the message to the brain, from which proceeded the command that the return messenger announces has been obeyed—say, to kick that piece of orange-peel from the pavement which some thoughtless person had thrown there. Then from that great main trunk the nerves all issue, running so entirely over the whole building—or, shall we say again, "temple"?—of the body, that, in a specimen in a glass case in the museum of the College of Surgeons in Lincoln's Inn Fields, the human skeleton, standing in an upright position, appears to be literally covered with very minute silken threads from top to bottom, all the flesh having been removed, and nothing but the bones and nerves left. Here is the telegraph system at once both anticipated and illustrated; but who shall explain its mystery?

Next, awaiting our inspection as well as our reflection, is a transverse section of an adult optic nerve; this measures an eighth of an inch in diameter, and this again is the mysterious instrument which conveys the reflection of every object you and I have ever looked upon to the central telegraph station—I mean the brain, where it is "left till called for," when the mind, reading off from the picture left on the "*sensitized plate*," as

the photographer calls it, recalls the image; but what causes the retention of the image forty or fifty years after?

We may see multitudes of invisible muscular fibres, through which once ran the nerves carrying the pictures of the outer world to the brain of some member of our race—disintegrated bundles of invisible threadlets they are. These extremely delicate radiating fibres average the fifteen-thousandth part of an inch in diameter. They are aggregated into flattened bundles, and appear to be mechanically held together by a countless number of teeth, each one interlocking with the other.



Vertical section of human skin.

a, *epidermis*, the outer stratum or cuticle; *b*, the inner, or true skin; *c*, the coil of a sweat-duct, finding its outlet on the surface, *a*; between *a* and *b* is seen the pigment-cells which give colour to the skin.

And here you have what perhaps you will say is the most interesting of all our anatomical objects, the human skin from the hand. Observe, this is stained with three different colours, so that the various parts may be more easily distinguished. The entire body is covered with this wonderful clothing, which is composed of two layers—an inner, the *vera cutis*, or true skin, which usually makes up the largest part of its thickness; and the *epidermis*, which covers it. These two skins are separated by a thin bed of gelatinous sub-

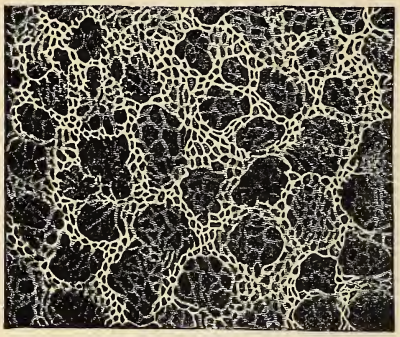
stance. There are no blood-vessels in the outer skin; its only object is to protect the inner skin with all its delicate nerves and vessels; and here is a very striking instance of design which this epidermis has "*acquired*" (?), for it has the power of growing faster than the other skin, where most it is wanted; that is, upon those parts which are most used, as if what we call "nature" foresaw the necessity, and made provision for it.

It is on such a slide that we see the distribution of the sweat-ducts, which have so much to do with health and disease. You behold them running from coiled-up bundles beneath both skins, embedded in deeper layers. These sweat-glands, you will perceive, consist of a tube, the opening of which is on the outside of the outer skin, and on one square inch of the palm of the hand there are as many as 3528;* they run up from their bundles into the epidermis in a corkscrew form, starting from a bed supplied with blood-vessels which are appointed to nourish them. Their number is astonishing; 2800 are said to be found in every square inch of the skin, and as there are 2500 square inches on an average-sized human body, it will follow that their number over the whole body will amount at least to seven millions. You will see that these glands take a wave-like direction from their base to their summit. When straightened they will measure a quarter of an inch in length, so if all their tubing were placed end to end it would amount to 1,750,000 inches, or 145,833 feet, or 48,611 yards, which is upwards of 27 miles.† And the health and comfort of a lifetime greatly depends upon the correct performance of all this system of main drainage, without any power of ours to alter it, though, on the whole, we may help or hinder it.

* Erasmus Wilson. † Dr. Lawson.

I have already told you that in the human lungs there are six hundred *millions* of air-cells. You shall now see with your own eyes what these air-cells are, first in health, and then in disease. Tell me, then, if we are not "fearfully and wonderfully made," and whether a house so marvellously constructed should not have a tenant in every respect worthy of its glorious Builder.

Here, then, first, is a preparation of the human lung.



Air-cells of the human lung.

The whole interior, you perceive, is divided into a multitude of air-cells, which freely communicate with each other, and with the ultimate ramifications of the air-tubes which the trachea, that is, the wind-pipe, subdivides; and the network of the blood-vessels is so disposed in the partitions between these almost countless cavities, that the blood is exposed to the air on both sides.

Such is a very brief and very imperfect reference to some few of the many wonders connected with our respiratory organs in health. Now let us see what that fatal disease called "consumption" looks like when seen with our microscope. "Why," you say, "this looks for all the world like a piece of mouldy flesh." That is, in my opinion, exactly what it is. The air-cells in our object are almost entirely destroyed by parasitic growth. Had you seen the doctor's certificate which accompanied the burial of the person from whose body this little bit of diseased lung was taken, you would have read the Greek

word "*Phthisis*," which being interpreted, means "*wasting away*." It is sometimes called "tubercular disease." We have already seen something of the blood, and we know something of the nature of that great pumping-station of the body we call the heart, which our forefathers long ago erroneously thought was the seat of the affections; and we have seen something, too, of that wonderful system of drainage which runs over the whole body, from the crown of the head to the sole of the foot; and now we are brought face to face with that fell disease which, unless taken in its earliest stage, ends in what we call death. What is it? You said it looked like a piece of mouldy flesh, and you were right. But what *is* mould? The tubercules which destroyed the lung from which our object was taken was the consequence of imperfect oxygenation of the blood of the owner, and that is what we are all more or less exposed to. Ah, if you were only to pay a visit to the Brompton Hospital for Consumption, and you did not return to your home with a grateful, a sympathetic, and a liberal heart—well, the more your shame!

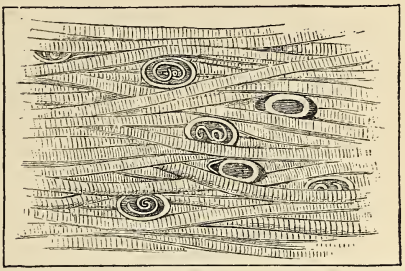
"He jests at scars that never felt a wound," says Shakespeare, and he says truly; but the right way to appreciate our own blessings is to become a little more familiar with others who have been deprived of theirs, for indeed it is true that "blessings *do* brighten when they take their flight," and instead of being frightened at a little imperfect knowledge of some of "the ills that flesh is heir to," we may learn to avoid some of the various ways which lead *to* them, and to thank God also for being kept *from* them. I have heard of one who, passing through the wards of a lunatic asylum one day where those were detained who were harmless, had one of them come up to him, and in that strange manner in which an

insane man addresses you, looking into his face he said, "I say, sir, did you thank God this morning for giving you the right use of your mind?" On receiving an honest answer in the negative, he replied, "No more did I; and that's why He has taken it away!" There *was* "method in *his* madness."

Look at another slide; it is marked "Striated fibre, human muscle." When we examine an ordinary piece of flesh, say of a rump-steak, with the naked eye, we observe that it is made up of a number of bundles of fibres, arranged side by side with great regularity, in the direction in which the muscle is to act: these bundles may be separated into smaller parts, and then they appear as they do in our specimen, as distinct fibres.

Our muscles, then, are of different kinds, as our nerves are, and just as there are nerves of sensation and nerves of motion, so are there muscles of volition and muscles of involition, and these voluntary and involuntary muscles are of two different forms in their structure; one, the voluntary, is striated, that is, marked or impressed with thread-like lines; you will see this with our highest magnifying power, and, remember, it is significant of the extreme fineness of their structure, that our sixth, objective, whose power with the "A" eye-piece is 240 diameters, and with the "D" 910, and whose superficial power, therefore, is, 828,100 times, is necessary to count these otherwise invisible striated fibres which lie so closely packed behind or next each other; but, though imperceptible to us, even with this excellent lens, there is a space between each. Now, that space is the hunting-ground of another disease, and, however uncertain we may be of the natural history of the malady we call "*consumption*," whether it be morbid vegetable growth or not, it leaves us in no doubt about the cause of the equally fatal

and more mysterious disease called "*Trichinosis;*" in the examination of which we shall see that it *is* possible for a man to be eaten up of worms; and we shall learn a solemn and perhaps a useful lesson, that just as the introduction of an invisible enemy will destroy the body, so may it be with the soul.



Voluntary muscle, with two distinct attacks of trichinæ. Drawn from nature.

Here, then, are striated fibres of the human muscle between which you will see coiled up in an oblong cyst (another Greek word, signifying a bladder) an undoubted animal of a worm-like nature; and as this specimen came to me from a good and clever man * who prepared it, and who knew something of the unfortunate victim of the disease, I will tell you what he has told me. But, here again, don't say, "No, whilst ignorance is bliss 'tis folly to be wise." You need not be alarmed; it is only those who *will* eat raw or badly cooked and inferior meat who are exposed to such a terrible disease as trichinosis. Well, then, if you are not a coward, listen!

A few years ago a man was driving a cart down one of the crowded thoroughfares of the city near the London Hospital. He fell down, apparently in a fit, and was taken to the hospital, where, soon after, the poor fellow died. When the inquest was held upon the body, it was discovered that death was produced by a *second* swarm of trichinæ; from the *first* he had recovered, and those dark

* Mr. J. T. Norman of the City Road.

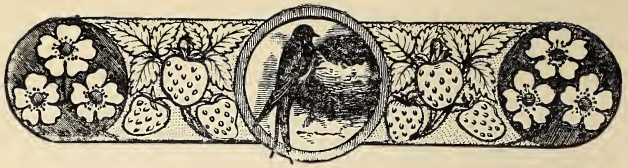
and empty cysts you see on our object were those which *first* attacked the muscle, between the voluntary fibre of which you see they are concealed. Those which come more clearly into view, are those which produced his death. My friend tells me that the subject from which he made this preparation was a German who had been in England twenty years; he had been ill on several occasions, and had been in the habit of receiving sausage-meat from his relations in Germany, which was no doubt the means by which he was trichinised, as on several occasions after eating it he was taken ill, but never bad enough to be laid up, the illness passing off as an attack of ordinary diarrhœa, calling for no medical assistance. I have told you his death was occasioned by what at first appeared to be a fit of some kind. On a post-mortem examination being made, his muscles were found to be filled with trichinæ in most extraordinary numbers; on a moderate calculation, his body was supposed to have contained between fifty and sixty millions of these parasites.

I might thus entertain—no, don't say "*frighten*"—you with other illustrations of the human body, in health and disease; but perhaps you may exclaim, "*Hold, enough!*" And so we will leave the investigation of bone and sinew, and teeth and nail, and other of the many complicated parts of the wonderful house we live in; and I can only hope to have sharpened the edge of your intellectual appetite, and to send you to other and better guides for increased instruction; but you will read and study in vain unless you can endorse Thomas Carlyle's words, that man's twofold nature is reflected in history. He is of earth, but his thoughts are with the stars. Mean and petty too oft his wants and his desires are; yet they serve a soul exalted with grand, glorious aims, with immortal longings, with thoughts which sweep the heavens, and

wander through eternity. A pigmy standing on the outward crust of this small planet, yet his far-reaching spirit stretches outwards to the infinite, and there alone finds rest.

I have already reminded you that it is truly a most Christian exercise to extract a sentiment of piety from what is called "*Nature;*" and, if you are not above listening a little further to her still small voice, as we pursue our microscopical studies, you will endorse the pious exclamation of the Christian poet Milton, who, looking "from Nature up to Nature's God," exclaimed—

"These are thy glorious works, Parent of good,
Almighty! Thine this universal frame,
Thus wondrous fair: Thyself how wondrous then!
Unspeakable! who sitt'st above these heavens
To us invisible, or dimly seen
In these Thy lowest works; yet these declare
Thy goodness beyond thought, and power divine."



CHAPTER IX.

POND-LIFE.

"Let the waters bring forth abundantly."—Gen. i. 20.

"How calmly may we commit ourselves to the hands of Him who bears up the world—of Him who has created, and who provides for the joys even of insects, as carefully as if He were their Father!"—Richter.

I AM indebted to a friend for the following story. He was present at a meeting of naval and military officers held at Portsmouth recently, when experiments were made with some new application of machinery in the construction of submarine torpedoes, and after witnessing the character of these dreadful war-ministers, he was introduced to the inventor, to whom he then showed some of the marvels of pond-life with his microscope, and in one little drop of water, not larger than a pin's head, an ordinary rotifer appeared with the cilia resembling an invisible rotatory wheel in rapid circulation, producing that vortex in the surrounding water into which all the smaller animalculæ falling, became its prey. His consternation on beholding the complex machinery of the invisible animalculæ was equal to my friend's at the marvellous display of intelligence in his implements of destruction, and he appeared

to realize the truth of his own exclamation, that "he was outdone after all."

In studying the contrasts in nature, no more interesting experiment can be made than taking a drop of water and placing it in the live-box, and then viewing it with a moderate power under the microscope with the aid of the spot lens, an invaluable dark-ground illuminator, having the light thrown on to the mirror from the flat side of the bull's-eye lens; and here let me remind you that the thin edge of the flame of the lamp is that which should always be used, when the petroleum, if it be the best—that is, what is called "water-white"—will give a pure white and steady light.

It would have spread out my story far beyond its limits were I to attempt to enter upon the manifold *et ceteras* of the instrument or its management: that is not my object here. When I began my microscopical studies I had very little exterior aid; I found the greatest aid from close personal observation. I worked on, remembering the little song, "If at first you don't succeed, try again," until I learned all I needed to know. I recommend every beginner to provide himself with a copy of Jabez Hogg's book on the microscope, if he would know all that *he* will need to know on the history of the instrument that has been so useful to the world during the last quarter of a century. There he will find, in easy and unscientific language, a work copiously illustrated, all about the mechanical and optical principles in the construction of the microscope, its lenses, illumination, and apparatus, together with popular illustrations of the marvels of the invisible world. Should that work be beyond his reach, then the little book of the late Mr. Wood, "The Common Objects of the Microscope," will give him a wonderfully cheap shilling's worth of readable in-

formation, which will both amuse and instruct him. But beyond and above all things, let me very strongly advise him never to think of investing in a microscope, however humble it be, without consulting some one able to advise him as to the best way to get the best return for the money he may have to spend, or the probability will be that he will have to begin all over again, or give it up in disgust. There is a never-ending amount of bewonderment and delight in the study of what is called "pond-life;" it is necessary to be provided with one of Baker's fishing-rods—a telescopic walking-stick, admirably contrived, so as to serve the purpose of a travelling companion, and an assistant as well in getting some of the objects from the water too far from the land to be reached otherwise. When the stick is extended, there is attached to it a ring into which a wide-mouthed bottle, which accompanies the stick, as well as a hooked knife to cut off the aquatic weeds, is affixed; and then a little world may be easily caught, and the bottle detached from the rod, and the contents, being secured with a screw top, will create such an amount of astonishment as to be believed must be witnessed.

It is nine and twenty years ago since in this way I first went a-fishing. I was advised to go to what was called the "Black Sea," a pond on Wandsworth Common, and I fished in hope. I knew nothing then of the names or character of any of the wonderful things my eye was to behold, and, being very enthusiastic, I surveyed a tiny drop of the water on my return home. It was very late at night, and my family had retired to rest; but when I put the smallest possible drop into the live-box and perceived, for the first time, the clever and very lively *melicerta* at work with the sensitive vorticella on its long spiral stalk, its cilia revolving, or appearing to

revolve, after the fashion of the paddle-wheel of a steamboat; as I saw the vortex produced by it, and the remarkable manner in which it caught the smaller animalcule, taking it into its transparent body; and then when, employing my highest power, I succeeded in finding a very delicate muscle running from end to end of that fragile stalk, which held the creature to the bit of weed I put into the box—you will not wonder at my astonishment being equal to the torpedo-inventor, who exclaimed he was outdone after all; nor will you be surprised at my actually bringing some of my loved ones out of their beds to witness the wonderful things I had found in that prolific pond.

The *melicerta*, so well known to every experienced microscopist, may, I think, be called the prince of rotifers —a class of animals called *Rotifera*, by reason of the rotatory motion in the water produced by cilia surrounding the mouth, giving it exactly the appearance of a wheel, very actively rotating by means of minute machinery concealed in its transparent body. But first a word or two about the *vorticella*.

In a very interesting volume in my possession, published in 1743, there is the first account I have found of this remarkable creature. The author, one of the Fellows of the Royal Society, Henry Baker by name, describes it thus: "In several of Mr. Leeuwenhoek's letters to the Royal Society, we meet with an account of some surprising animalcules found adhering to the roots of duck-weed (which in summer-time floats plentifully on the surface of ponds and ditches) as examined by him in a glass tube filled with water; one of these was shaped like bells with long tails, whereby they fastened themselves to the roots of the weeds; and sometimes twenty of these were seen together, gently extending their long

tails and bodies, and then in an instant contracting them

Pond-life, highly magnified (see p. 234).

"Infinite riches in a little room."

again." Clearly this is the *Vorticella.* Then follows, with

equal clearness, the *Melicerta*, and I quote the author's exact words only to show how observant and correct our forefathers were, who had such very imperfect instruments to work with, so that the most juvenile of students with the humblest of microscopes may learn from them a lesson of perseverance.

"Another extraordinary kind of animalcule," says this old writer, "appears in a sheath, or case, the end whereof it fastens to the duck-weed roots. This little creature has two seeming wheels, with a great many teeth or notches coming from its head, and turning round as it were upon an axis. At the least touch it draws the wheel-work into its body, and its body into the sheath, after which it appears concealed; but when all is quiet it thrusts itself out again, and the rotation of the wheel-work is renewed."

To another Fellow of the Royal Society, the late Christian philosopher, Philip Henry Gosse, who but recently passed away from us, we are indebted for a full explanation of this wonderful illustration of the almightiness of God shown in little things. His description of what he properly calls the architectural instincts of *melicerta* will greatly interest any one who has had the good fortune to witness the movements of this busy little rotifer. He says it is an animalcule so minute as to be with difficulty appreciable to the naked eye, inhabiting a tube composed of pellets, which it forms and lays one by one. It is a mason, who not only builds his mansion brick by brick, but makes his bricks as he goes on from substances which he collects around him, shaping them upon a mould which he carries upon his body. Mr. Gosse seems to believe that its first discoverer was Linnæus, the Swedish naturalist, who flourished about a hundred and sixty years ago. The very best comparison that could have been made by Mr. Gosse was when he likened

the cilia in motion round the head of *melicerta* to one of those circular ventilators which used to be seen in one of the upper panes of a kitchen window, running round and round for the cure of smoky chimneys. One, to whom I am greatly indebted for much of my little knowledge of natural history, told me that he had removed one of the "bricks," or small pellets, and that immediately another was moulded from the inside—the whole process being revealed by the transparency of the creature's body—and deposited in its place by what looked like the first finger and thumb of a man's hand, both working together in the moulding of the "bricks."

The *vorticella* is very much less in size than the *melicerta*, but has similar interest for us in the wonderful construction of its infinitely little transparent body. The "tail" of the old author is in truth a long flexible stalk, one end being attached to the stem or leaves of an aquatic plant, commonly called "lemna," or duck-weed, through the entire length of which runs the muscular thread, the discovery of which, in one of my earliest examinations, required a magnifying power of about a million of times superficial. "When in activity and secure from danger," says Mr. Hogg, from whose very useful volume some of the foregoing has been taken, "the little vorticella stretches its stalk to the utmost, whilst its fringe of cilia is constantly drawing to its mouth any luckless animalcule that may come within the influence of the vortex it creates; but at the least alarm the cilia vanish, and the stalk, with the rapidity of lightning, draws itself up into a little spiral coil."

How often have I been astonished at witnessing the extreme sensitiveness of this inhabitant of the invisible world! Simply by tapping the instrument, while the little thing is hunting for its food, it withdraws itself

into its transparent dwelling by the contraction of its muscular stalk, gradually extending itself directly it has recovered from the shock. How many thoughts which positively bewilder one does such an insignificant thing as this suggest!

Has this minute object in creation, then, a brain, since a brain is the seat of sensation in every animal?

Group of Vorticellæ.

Evidently there is as true muscular action as we superior animals have. But the wonders of this speck of vitality are by no means confined to the appearance it will present when you find it revealing, apparently, its complicated machinery, for its little life is not always to be affixed to the weed upon which we find it. There are no organs of locomotion visible in the *Vorticella* while it is attached to the stalk, which limits its sphere to the spot on which we

may see it; but for the purpose of propagation, when the proper period arrives, at the lower end of the body, at the point of its junction with the stalk, a new fringe of cilia is developed; and when this is fully formed, the vorticella quits its stalk and casts itself freely upon its world of waters.

Pond-life! "I am free to confess," writes Mr. Gosse, "that among all classes of animated beings the *Rotifera* has been my own special delight. Their numerous and varied forms, often of remarkable symmetry and elegance, their swiftly revolving wheels, their vigorous and sprightly motions, their curious habits and instincts, their complex organization, and the ease and correctness with which this is discerned through their tissues, which have the transparent brilliance of the purest crystal—all combine to impart a charm to the wheel-bearers, which make the observer hail their appearance in his drop of water with pleasure, and linger over them with unwearied delight."

Their little lives are indeed like a romance. You may observe all its processes by dropping a little colouring matter into the water in which you have found them, and as the minute particles, either of indigo or carmine, pass along their little canals, their envelopes being perfectly transparent, the whole of the machinery of their exquisitely perfect little bodies may be easily observed.

Should it be asked what is the use of these apparently useless little things—these to us invisible inhabitants of the watery world—Professor Owen tells us that they are the "invisible scavengers" who are appointed to preserve, not only the purity of the water, but the salubrity of the atmosphere, for they are found everywhere. Heated water will not destroy them, for they know how to preserve an atmosphere around their curious bodies just cool enough to preserve life; nor will frozen water exterminate them, for

they know how to preserve a little volume of warm air around them, which has the same effect in keeping them alive. And when they have converted the dead and decomposing particles of matter which they find in the element in which they live into their own living tissues by that mysterious process we call "assimilation," they themselves become food for larger infusoria and of numerous other small animals, which in *their* turn are devoured by larger animals, and thus a food fit for the nourishment of the highest organized beings is brought together by a short route, from the extremity of the realms of organized matter.

Pond-life! No branch of microscopical work can be better studied, as an evidence of the wisdom of God displayed in creation, than the forms and movements of the minute inhabitants of stagnant waters or streams. Their organs of locomotion are astonishing; they appear to move about at their own free will, without the interference of anything else, and they hold on to an object with what appears to be voluntary adhesion; and their mode of reproduction, too, is most curious, for in some species it is by division, while in others it is by budding. All day and all night these active little "scavengers" are busy employing their short lives in clearing the water from offensive matter, and they appear to enjoy their existence, brief though it be. How many thousands may be found in a drop of water not larger than a pin's head it is not safe to repeat, but they are simply countless.

May we not conclude these very brief remarks on pond-life with a reference to the best of authors in the best of books?—"These wait all upon Thee; that Thou mayest give them their meat in due season. That thou givest them they gather: Thou openest Thine hand, they are filled with good. . . . Thou takest away their breath.

they die, and return to their dust." "Let the waters bring forth abundantly," was the command; how perfectly has it been obeyed!

"Infinite Riches in a Little Room."

The reader, who may be a stranger to the world of wonders to be found in a drop of water, may be told that in the cut at p. 228 are represented in a group some of the most striking specimens of animal and vegetable life to be found in our ponds. Confervoid plants in this admirably engraved cut afford everything needful to the animals seen in it: there is the water-flea, *Cyclops* (with its one eye), at the bottom; and immediately over it, in its transparent house, supported on its foot-stalk, one of the most beautiful species of Zoophytes, the *Stephanoceros*, with its beautiful crown and active cilia, occupying the centre of the cut; immediately to its left *Melicerta* is seen with extended cilia; and directly over that is the strange-looking transparent body of the *Water-bear*, in two forms, bending over, and turning round the branch of an aquatic plant. Rotifers of several kinds are seen busily occupied in swimming in what to them is a river of water; and, near the top on the right hand, is the *Volvox globator*, a little vegetable centre of life with future worlds visible through its transparent envelope, rotating on its own axis in the stream just as our world does in air; its diameter is only the thirtieth of an inch, the minute green spots visible on its surface, each of which is a cell, being only the 3500th part of an inch in size.

CHAPTER X.

MISCELLANEOUS.

"What a wonderful Workman is God, in miniature as well as in the great! With the one hand, perhaps, He is making a ring of one hundred thousand miles in diameter to revolve round a planet like Saturn, and with the other is forming a tooth in the ray of a feather of a humming-bird, or a point in the foot of a microscopic insect. When He works in miniature, everything is gilded, polished, and perfect; but whatever is made by human art, as a needle, etc., when viewed by a microscope, appears rough and coarse and bungling."—PALEY.

YOU will not be surprised at my continued devotion to studies in which the microscope is a necessary companion. There is hardly anything that this may not be applied to with widening interest. No one knows what treasures lie mysteriously concealed in the flowers of his garden; nor of the gladness and astonishment which only await a quiet hour and an experienced teacher to bring them to light. Let me give you a striking illustration.

Some friends, to whom I had promised an evening with the instrument, begged that they might be allowed to bring another with them, and I was thus introduced to the stranger, a venerable matron of quite my own age, whose husband had been a well-known character in the literary and scientific world, and who was more especially

devoted to the natural history of ferns, having written and published much about them, a copy of one of whose books the lady brought with her. The following is something like the conversation which took place between us.

"So you know something about ferns?"

"I should," was the reply; "for many years of my life have been spent, in connection with my late husband, in their study."

"And in flowers too?" I said.

"Yes," she replied, "in flowers too."

"Let me show you some of my ferns and flowers, then, as it is always well to begin with what we already know something about."

I then asked if she knew much of the structure of ferns or flowers, and found her knowledge was confined to their species, genera, and growth. Her husband had used a "magnifying glass" in their examination, she said, but she had never beheld their structure through such a microscope as she now saw; nor did she wish to, as her sentimental fondness for both ferns and flowers did not approve of their being "torn to pieces." The dear old lady had a face beaming with intelligence and goodness, and as the face is the index of the mind, looking into it, I said—

"I think I could make a convert of you, if you will allow me to try."

"No, thank you," she emphatically replied; "you could not. I'm too old to learn, and don't wish to begin again."

After a little persuasion, with the conviction that I had the right kind of material to work upon, I succeeded in tempting her to look down the magic tube. I had separated the stamen and pistil of one of the Japanese anemones then so beautifully blooming in our garden. She looked, first at it, and then at me, and then gently

exclaimed, "Well, I've never seen anything *like that!*" then, coaxingly leading her up the botanical ladder, at last I got to the ferns which she fancied she knew all about, and you should have seen her amazement and delight as the spores fortunately burst from their golden cases, distributing themselves before her eyes. We wound up a couple of charming hours with the circulation in the leaf of the Anacharis, when, with the fourth eye-piece, a good sixth object-glass, and extended draw-tube, the superficial measurement of that little leaf measuring only one-tenth of an inch by one-eighth in length and breadth, there may be seen an average of 315,000 moving granules of chlorophyll,—"grass-green" bodies, each revolving in its individual cell, in 6300 cells into which the leaf is divided, and then the "conversion" was complete, when the convert exclaimed—

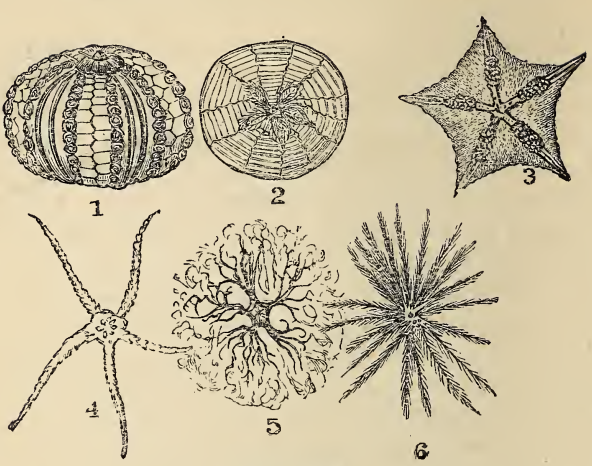
"I should like to stay here all night! When *may* I come again?"

How very different this result to others! One, to whom I explained the nature of the gritty tissue in a pear, exclaimed, "I don't care about gritty tissue; give me the pear to eat!" I have already told you of another, who said all he should care about the microscope would be—would it magnify the balance at his banker's?

"They that go down to the sea in ships, that do business in great waters; these see the works of the Lord, and His wonders in the deep," says one revelation,* and what says the other?

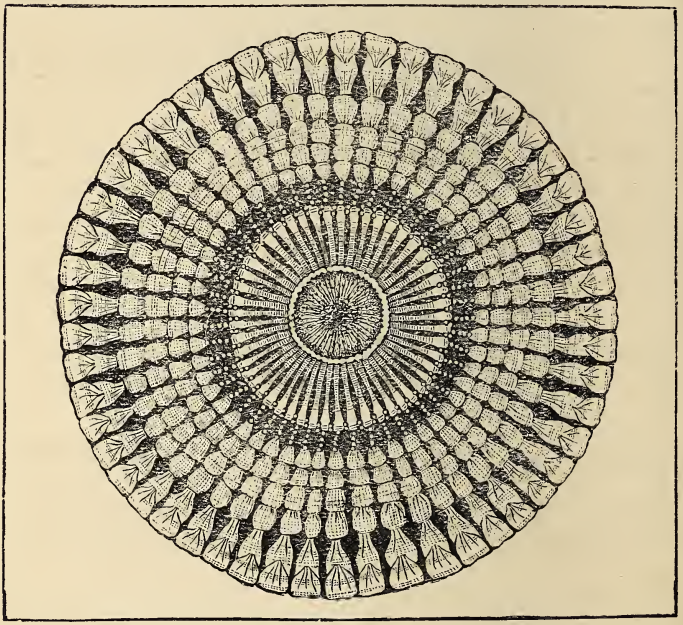
Did you ever think of the curious nature of many of the humbler classes of animal life; of the admirable contrivance of the plates which compose that remarkable piece of divine workmanship we see in an echinus-shell; or the

* Ps. cvii. 23, 24



Star-fishes.

1, Echinus; 2, Cake-urchin; 3, Star-fish; 4, Snake-star; 5, Sea-basket; 6, Feather-star.



Transverse section of the spine of Echinus, magnified 784 times.

beauty of many of the star-fishes; or, still more, in the section of one of the wonderful spines of that echinus,* an

A family of corals built up in the form of an oak, each "bud" affording a lodging for a colony of animals.

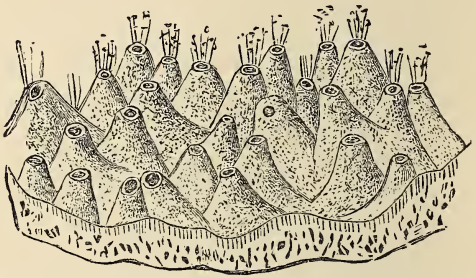
admirable and faithful copy of which I borrow from a former work and introduce here?

Do you know what coral is, or a coral reef, or of islands built up through many years by the persistent creatures

* See "The Unwritten Record" for further particulars.

who worked together beneath the mighty deep, erroneously called "coral *insects*," ages before the appearance of the human race? May I remind you?* The consideration has turned *my* philosophy into divinity. Or, can I look upon that most marvellous proof of the almightiness of God as seen in the contrasts of nature in the zoophytic life of the common Sertularia, commonly called seaweed, which may be found in almost all parts of our coasts, without emotion? Would I be so soulless?

Our admirably drawn cut on p. 242 will faithfully show



A piece of common sponge, showing the oscula, with currents of water passing out.

you what a vast family may lie concealed in what, to the unaided eye, appears to be an infinitely small branch of seaweed, but which is nothing but the self-erected dwelling of many thousands of microscopic creatures—one set agreeing to construct their habitations in this direction, and another in that; while the whole colony unite in presenting us with their exquisite fern-like total, where we find a separate creature in each of the tiny dots on each part of the several fronds. Also perhaps, on the same bit of rock upon which the sertularia is found, there may be discovered a portion of marine sponge

* See Appendix.

Sertularia: a marine zoophyte.

actively employed ejecting the water from its inside, and while resembling a number of infinitely little volcanoes, it is in fact nothing but a small bit of living jelly.

"If one branch of this plant-like family be examined with a moderately powerful lens, it will be seen to consist of a horny stem, each branch being studded with a double row of little cells, open at the mouth, which is much smaller than the base. If the same be placed in clear sea-water and still watched through the lens, from each cell will be seen to protrude a tiny polyp" (similar to that shown on p. 197), "whose star-like head is all that is visible externally."* The small branch on the right of our cut is about the average size of such as may very frequently be found on the shell of an escalop; but an East Indian specimen, three feet long, is said to have been so large that it contained 800 millions of living polyps, about equal to three-fifths of the population of the whole earth. On the above-mentioned branch there might have been upwards of three thousand of these living creatures which had built their own houses in a plant-like fashion.

Patient examination of the most common objects for the microscope will disclose many beautiful instances of the wonderful care which an All-wise Providence has ever exercised over the smallest of His creatures, and many useful conclusions thereby suggest themselves to a devout mind. In the insect-world, which will afford, perhaps, some of the most remarkable instances of this nature, one fact is very observable—the method employed by some of the great family for the protection of their young. "Men," says Professor Rennie—"men, indeed, proceed by means of reasoning and experiment to the discovery of such materials as are best fitted for protecting their

* Wood's "Common Objects of the Sea-shore."

bodies against the vicissitudes of temperature, and other changes of the weather; while insects are taught by the Governor of the universe to select instinctively the best materials for their clothing."

Before the introduction of coal colours, the little cochineal insect afforded a large contribution to the stores of commerce, giving us an interesting illustration of the rapid progress made in the production of one species only, namely, that of the Canary Islands, where the cochineal insect, that which produces the beautiful colour known as carmine, was first brought into competition with its fellows from Honduras. In the year 1831, the total produce of Teneriffe was eight pounds of cochineal, and, while writing of this once precious insect, its value may be imagined when I tell you what a rich Yorkshire dyer once told me, that when the dye was first discovered, his father and another man joined in the purchase of one bag, which, because of its costly nature, they kept under their bed. It was and still is in the London market called "*grain*," and this is how it came to pass that it was thus called. The dried insect is so like seed that it was believed, two centuries ago, to have belonged not to the animal but the vegetable kingdom. In a curious volume in my possession, written by Lemery more than a hundred and fifty years since, there is a very amusing description of the "article" which has played an important part since in the commerce of London. In this antique work it says, "The Cochenelle is the seed of a plant about two or three feet high, adorned with Leaves two Fingers thick, of a beautiful Green, and very prickly" (he is evidently referring to the cactus, upon which cochineal insects chiefly feed); "after which grow Buds or Husks in form of a Heart, of a Green, tending to a Yellow Colour, in which are enclosed a

Quantity of small Seeds, of the size of a great Pin's Head, partly of a flat Figure, almost triangular, of a greyish Silver Colour to the Eye, and as red as Blood within."

Then follows a very curious argument in good Old English, as to whether the thing is animal or vegetable, from various scientific men of those days, and, as it was decided that it was the latter, it was called "*grain*," by which name it has been called ever since. The article concludes thus in favour of the vegetable family of the thing: "Besides this there are other things which deserve our Credit, as that we cannot discover the Feet, Wings, Head, or any other part of an animal in the Cochenelle, which we have, or in all those observations that are made of the true Grain, and if these proofs are not sufficient, we may look into the Judgment of Ximenes and William Piso, in his 'History of the Plants of Brazil,' where, after he has given a long Description of the Species of the Indian Fig, he says it is the same Plant that in New Spain produces and bears the Cochenelle."

The *first* importation into England of this "grain," from Teneriffe, as I have said, was in the year 1831, and it then amounted to 8 lbs.; the next year it reached 120 lbs.; the next 1319 lbs.; and gradually increasing every year, by 1853, when I last "took stock" of the Teneriffe "article," it reached 790,524 lbs.; but five years after that the total importation into London alone was, from Teneriffe, Honduras, and Mexico, 13,000 bags, whose average weight was at the least 150 lbs. each, or 1,950,000 lbs. I had the curiosity to weigh one ounce of this so-called "grain," and I counted 3350 insects necessary to make up that weight, so that one year's importation of the cochineal insect into London *alone* amounted to the astonishing number of one hundred and four billions five hundred and twenty millions, which, counting at the rate

of two hundred every minute in every twelve hours, without intermission, would have required more than two millions of years to reckon up. Their market value, in the year in which I made this curious calculation, amounted to £350,000.

But we began this apparently out-of-place story with an allusion to the remarkable manner in which some insects preserve their young; and, because this is displayed in the case of the cochineal insect, I have introduced the curious account from the oldest book in my possession.

When the apparently loving mother begins to provide for her family, which is not to emerge that season, "she stoops down and deposits her eggs under her body, which become glued to the spot; she then dies, and her body becomes a covering for the eggs. In this state the insects appear on the bark of trees like small warts, some species in the form of a boat, some kidney-shaped, and others globular; and, before their history was understood, they were, with some plausibility, supposed to be vegetable galls by the French." *

Why have I introduced the story of the cochineal insect here? Because it serves to direct your attention to another species—a *Coccus*, also of the cochineal family, —which may be found both upon apples and oranges, and which may enable you to instruct and very much amuse your young friends.

You may have seen, especially upon an orange, very small mussel-shaped, dark-brown specks glued on to the rind. When I first took notice of these little specks, wondering what they could be, I carefully detached several, and, on turning them over, to my great surprise I found them filled with eggs, carefully packed in the hollow shell-like covering, and preserved with what

* Rennie.

resembled very fine silk stowed between one and the other, evidently to keep them from injury. I placed one of these curious things on a slip of glass and laid it on the stage of the microscope, and threw a flood of light into the hollow egg-boat, which the observant author of "Insect Transformations" (a very useful and interesting book on entomology, and one of the most reliable and readable too, in my opinion, that a lover of nature can desire) tells us is the dead body of the mother, and which singularly reminds us of the fabled Phœnix. What was my astonishment when the heat from the flame, falling from the convex side of the condensing lens, brought the insects to life, and, breaking through the shell that covered them, there I had the delight of beholding the secret of artificial hatching, while the living and very minute creatures made their first appearance in their perfect form!

The soft downy substance, so carefully deposited between the eggs, sorely puzzled me, and so did the singular covering; and I only discovered that this little dark-brown speck was the shrivelled body of the fond mother laid over the offspring she was never to see, when I found a similar story related in the work last referred to, where the amiable author, describing a similar coccus, says, "Those which are found in our green-houses, and which are the pest of the grape-vines in the neighbourhood of London, both in and out of doors, secrete a sort of white silky gum, very like gossamer, as the first bed of their eggs. Réamur could not discover that the mother insect was furnished with any organ similar to those of spiders and caterpillars for spinning this gossamer. We may remark that the covering formed by the body of the mother coccus prevents this substance from drying, as the webs of spiders do, and, consequently, it can at any

time be drawn out into extended threads, by detaching a few of the eggs from the mass."

The reference here to spider's eggs will bring to your remembrance my former story of the nest made of spider's silk in which 240 eggs were found, and which also enclosed a big bluebottle; from it we learned one of the very best "lessons" the microscope can teach, namely, that of unselfishness.

But this illustration of maternal love, as exhibited in this humble inhabitant of the invisible world, would never have been discovered without the aid of the microscope. It has afforded much merriment to the young and astonishment to the old, as one egg after another, artificially hatched, liberated its prisoner. One night I had a lecture to deliver, entitled "Life amongst the Insects." It was at the West End of London, and as I had made a diagram of the mussel-shaped covering, and had drawn a portrait from the life of one of the little creatures, I thought, however, that an object illustration would be a useful addition to my picture; so, finding an old woman sitting at a stall, I proceeded to purchase a penny orange. I turned one after another of the fruit over and over without finding a single coccus, and the old Irish lady began to wonder what in the world I was after, and she looked suspiciously at what I was doing, till I thought it would be kind to gratify her curiosity, and at last, finding one, "You see," I began, "this little speck?"

"Sure, and I do," she said.

"Well, mother, do you know this is the body of *another* mother, which has become a cradle, in which are a number of sleeping babies, all waiting the light of the world to bring them to life?"

I gave her the penny, which she looked at suspiciously, and I verily believe that she thought I was an escaped

lunatic, or else that the roll of diagrams under my arm was an infernal machine.

While writing this page I have before me an apple from Tasmania. On it I have counted fourteen of these cocci, so that they flourish as much in Australia as in Sicily and in England; but what would my grandfather, who was living in 1829, have thought of the man who should have prophesied that sixty years after, apples, in the finest condition, would be brought from the other side of the world in a big ship propelled by steam, in about five weeks! Or that his son's son would have an instrument by means of which the families of fourteen mothers, who had covered their numerous offspring *outside* with their own dead bodies on one of such apples, would be studied, as they lay sleeping in their cradles, comfortably tucked up *inside* with silken material spun out of their parent's body, and of his descendant's ability, with the aid of his instrument, to bring them to life!

On passing a station on the Brighton line recently, the train stopping in front of a book-stall there, a fellow-passenger, putting his head out of the carriage window, called out, "Have you a shilling romance?" What romance is to be found in natural history! Could any story in fiction be more romantic than the romance, in fact, of the Coccus family, or could a better illustration in the world be found showing that, in one form or another, from the highest to the lowest, one thing suffers or dies that another may live?

A mouldy lemon or a piece of lively cheese under the microscope affords infinite delight both to young and old; for, in the first you have a fairy botanical, and in the latter a fairy zoological, garden. We once had a servant who was provokingly fond of cheese for breakfast, *not* in *very* moderate quantities. Seeing that *our* share was

unusually lively, I said, "*I* will settle this cheese-for-breakfast business." So, placing a small bit on the microscope, I rang the bell, and said, "I want you, Mary, to look at *that*, and tell me if you know anything like it." It was night, and the bright light of the lamp illuminated the mass, so that with a moderately deep magnifying glass the mites looked like young sucking-pigs, running about as fast as their eight legs would carry them. You should have heard our Mary's exclamation as she said, "Oh, lor! *what is it?*" And when I assured her it was the bit of cheese which she had left at her early meal, she disappeared, and we never afterwards heard of Mary's desire for cheese for breakfast!

One may be reasonably surprised at the vitality which often is so long preserved in the eggs or pupæ of an insect, reminding us of the vitality of seeds, though in *them*, according to Dr. Carpenter, are many plants which spring up when a new cutting of some railway lays bare the virgin soil; such are not only of prehistoric, but it may be pre-Adamite origin, all light, heat, and moisture, the three ingredients necessary to growth, being excluded.

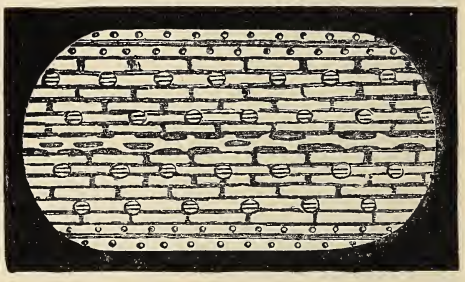
I have the best reason for believing the following story. A clerk employed at Guildhall, London, who was an entomologist, sitting one day at his desk, where he had been seated for twenty-two years, noticed what appeared to be a change in the colour of a spot in the mahogany before him; the next day he observed it became a small round hole, and on looking round he saw the pupa of a beetle, and presently out walked the imago—the perfect image, that is—of the insect. It must have laid there, he concluded, for upwards of a quarter of a century.

Let me strongly advise you to make any number of experiments with spiders, and especially with their webs: you will be well repaid with the result. You will discover

how they can dart out stiff threads, and sail upon the air by means of a float of fine filaments: that others travel in the skies by means of silken balloons which the spiders inflate and direct. A discharge of cannon at Kidderminster, some years ago, brought down a shower of aërial spiders, the explosion making the currents of air on which they floated too light to bear their weight. Cobwebs, like balloons, have been seen—some funnel-shaped, like parachutes—descending from the sky and falling upon the ground, and on examining them, small reddish spiders have been found carefully balanced within. If the weather be likely to be stormy, short terminating threads are used; if rain is approaching, spiders remain inactive; if they continue working during rain, fair weather may be expected. Every twenty-four hours alterations may be observed being made in spiders' webs: if these alterations be observed between six and seven in the evening, they indicate a clear and pleasant night. One species of gossamer is an excellent rope-dancer, seemingly delighted with darting its threads, ascending and descending in the air, balancing itself by closing its legs together, and promoting and directing its course as if nature had furnished it with wings or oars. Did Blondin know of this he would acknowledge himself to be as much outdone as did the inventor of the new torpedo when he saw the rotation of the wheel-like apparatus of the invisible Rotifer. Little space could be afforded here for the subject of Infusoria, but let me very strongly advise you to take up this delightful branch of miscroscopical study. There are said to be seven hundred species, and in one tiny drop of water five hundred millions are reported to have been seen, which, if true, is more than one-third the number of the population of the earth; and, remember that it is the great German naturalist, Ehrenberg, who

says they have heat enough to preserve a small circle of water unfrozen when all the rest is ice, and another circle to preserve coolness enough to sustain life when the temperature is raised to 200°, water boiling at 212°.

The most common object is often the most interesting, not only to a beginner but even to one well "up" in the use of the microscope. A piece of wheat-straw cut down the stalk, dividing it, then the siliceous skin stripped off and laid between two pieces of glass, with a low power, will disclose a world of wonders; and remember that it was the great "Starry Galileo," as he was called, who,



Siliceous cuticle of wheat-straw, the flinty skeleton only being seen (magnified).

when in his Spanish prison, where he lay persecuted for maintaining that the world went round the sun, said, while pointing to the common wheat-straw upon which he lay, "From the structure of that object alone, I can infer, with certainty, the existence of an intelligent Creator."

You will sometimes hear about "aids to faith." Did faith require aid from *without*, surely it were no longer faith. The palm tree in Scripture is the true emblem ot the righteous, and *its* growth is from within. Study the structure of plants, and you will be amazed at their glory and beauty and suggestiveness. "Consider the lilies, how they grow," and realize, in all its fulness, the profound

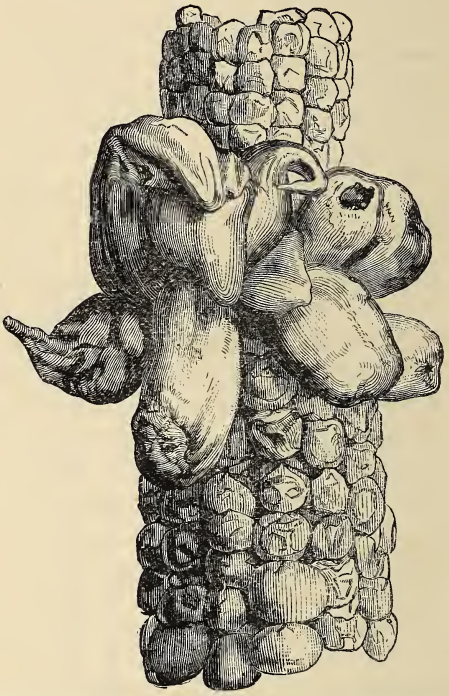
mystery of growth; and, if you love children, give them object-lessons with your microscope, and especially with flowers; show them "*how* they grow;" but remember, before you attempt to teach, you yourself must have been taught. Nature is the best of teachers, and her object-lessons commend themselves to every thoughtful mind; but that mind must have been prepared, or rather *pre-disposed*, to receive her deep truths, or they will fall upon stony or thorny ground, and bring no fruit to perfection.

Light, life, growth, fruit, this is the law, not only in the spiritual but the natural world; each is dependent upon the other, and if one of these four elements be omitted the end will be defeated: but what a mystery each of them is!

When you look at ferns and mosses, while you are amazed at their beauty, only think of their mysterious power of reproduction. The hart's-tongue fern has about eighty seed-vessels upon each frond, each vessel containing about fifty spores or seeds: each frond may be the bearer of from three to six thousand seeds, and upon the entire plant so many as eighteen millions have been reckoned.

The contrasts in nature will greatly interest and astonish you. If you examine what is called the "smut" in corn, from its striking resemblance to chimney-soot, there you will find that every tiny ultimate speck is a true vegetable, and that in one *grain* so many as four millions may be counted; then if you examine the beautiful structure of that Californian giant, the *Wellingtonia gigantea*, you will learn something of the mystery of growth in a tree that botanists tell us, by its annual marks, must have been four thousand years old, having only arrived at perfection when it stood twenty-three feet higher than St. Paul's Cathedral. Even in our own land the yew and oak will flourish over a thousand years.

The mystery of growth! We live in a world surrounded with mystery. Who can tell me how it is that I can keep up the circulation in the tiny leaf of a weed for three weeks after I have torn it from its branch? Anxious to know something of this mystery, I applied



"Smut" on maize (*Uredo segetum*), greatly magnified.

recently to a scientific friend of one of the profoundest naturalists of to-day; but mark the answer I received: "He can't tell you; he doesn't know himself." A willow weighing five pounds was put into two hundred pounds of dried earth a few years ago and kept watered, but covered;

in five years it had increased to 169 pounds, and the earth weighed two ounces only less than when the tree was first planted.

Who can popularly explain such phenomena as this?

It will be of little service your attempting to open the eyes of those to whom you exhibit the wonderful works of God as shown with a microscope, I must repeat, unless your own eyes have been opened, and unless you have grown in that inner knowledge which sees Him in His works, and are neither afraid nor ashamed to confess Him before men.

It has been well said that "a man may impart light to others who does not himself see the light;" but a pupil will think little of his teacher, and find his own growth little, if he hide the moral which the beautiful parables of nature are intended to teach. "It is true that a concave speculum, cut from a block of ice, concentrating the rays of the sun, will kindle touchwood or explode gunpowder; a teacher may set others on fire when his own heart is as cold as frost. It is true that he may stand like a stiff and lifeless finger-post, pointing the way on the road where he neither leads nor follows; yet it commonly happens that it is what comes *from* the heart of the teacher that penetrates and affects the hearts of his hearers. Like a ball red-hot from the cannon's mouth, he must burn himself who would set others on fire." *

In our examination of insects you will have observed much of the wonders of transformed life, and gathered some of the possibilities of the future as respects yourself. In passing from the caterpillar to the chrysalis, and from the chrysalis to the perfect insect, not only is the external appearance altered, but the various organs of support, motion, sensation, digestion, and reproduction are

* Dr. Guthrie.

also altered; but much remains yet to be discovered. The nerves of insects do not originate in a brain as in the higher order of animals, but in numerous nerve-bundles, as seen in our dissection of the caterpillar of a silkworm moth. What is the exact seat of their sense of hearing or smelling we do not at present know; their organs of digestion are very simple; that most important of all their little bodily parts, the circulation, is more easily observed and appears to flow very regularly, and in many parts of the body, as in spiders, with a distinct pulsation. Remember that, very distinctly, are the organs of respiration to be seen, for they communicate with the air by means of coils of spiral tubing, having sieve-like openings, or spiracles, very similar to the trachea and spiracle of plants, and being evidently formed for the same purpose.

Your entomological studies will do little for you if they do not suggest to you some of those great expectations which belong to the consideration of a future life. I wish to keep you constantly in mind of this, because my own life has been so very greatly benefited and blessed with the thought. You will be delighted in examining the wonders of moths and butterflies. Think, for example, of the wisdom given to the White Admiral butterfly. It deposits its eggs, which are almost exactly like the shell of an echinus, in July, on the upper surface of the leaf of the honeysuckle. In fourteen days they are hatched, when the young caterpillars commence life on their own account. The leaf falls in autumn, and each young creature, without any instruction from its mother, who died before it was born, is taught by instinct what to do; for, when it has eaten the leaf half-way, it begins to prepare for the future. Knowing that the leaf will drop, it spins a silken thread by which it is securely attached to the stem. It then folds up the remainder of the leaf, enclos-

ing itself in a very comfortable hammock, which, when the leaf in the course of nature falls off, swings to and fro like a sailor's cot in a gale of wind; but it is very secure, for the silken cord is elastic, and not easily detached, and being of the same colour as the stem of the honeysuckle, it is difficult to observe, and so the dreary winter passes away. The spring sun makes the bud, which the caterpillar knows somehow is situated in the axil of the old leaf-stalk, to burst forth and grow; and the same warmth awakes the sleeper. In April and May it feeds, in June it goes into a chrysalis, and in July it emerges as a large and beautiful butterfly; but what wonderful transformation has it experienced, and what grand lessons has it taught, in those twelve months!

Nothing in nature will astonish and delight you more than the study of the various mechanical arrangements by which insects are able to accomplish the great work they have to do; much will be beyond your comprehension, and you will only really have arrived at the secret of all knowledge when you have discovered that you know nothing, and that you are compelled to believe much that you cannot understand; and this is what is called *faith.*

There are six thousand species of those extraordinary flowers, the orchids, according to Lindley, from whom Mr. Darwin quotes; and the latter tells us—and *there* I can accept his theory—that the act of fertilization in that large family is almost invariably left to insects; and their study will of necessity take you to the study of structural botany, and how charming are the lessons belonging to that branch of natural history!

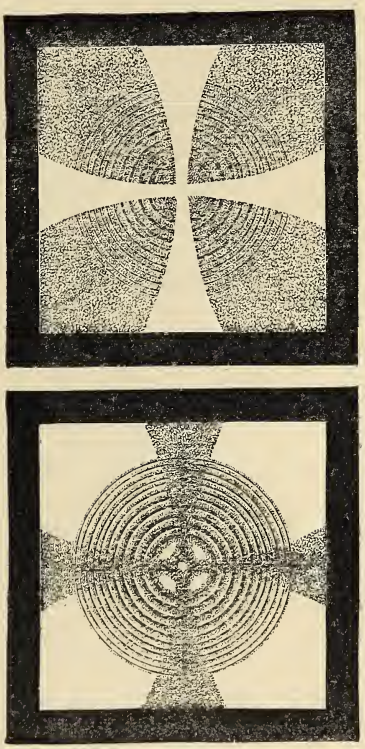
When you look again at one of the common but exquisitely formed capsules of the *Funaria* moss, think that it flourishes best wherever wood or straw has been burnt

in the fields. In summer and autumn, when all other plants are hard at work, it rests; in winter it works, filling its little capsules with thousands of spores, and in spring it disperses them. It is the pioneer of vegetation, where before all was desolation; and this is the order—first the moss, then the grass, then smaller ferns, then the larger ones; then the small, and after that, the larger trees. Their motto is what yours and mine must be in our microscopical studies—"by little and little."

Our microscopical "meditation at eventide" would be incomplete without some reference to what is called "polarized light." Should any one ask, What is polarized light? all that can be said is, "Polarized light is—polarized light."

Next to the great and undiscovered mystery of life, light is the greatest of mysteries. "God is light," the Bible tells us; and that metaphor is the best of all metaphors, not only because it is in the Bible, but also because a great deal that we know of God as therein revealed is very remarkably allegorized by light. Our accessories in the study of this important branch of microscopical science consist of a prism and an analyzer: the former is placed under the stage, and the latter nearest the eye; both are prisms made of Iceland spar, and the thin film of *selenite*, which greatly assists the polarization, is sulphate of lime, each being a pure and perfect crystallization of chalk, or rather of what is called plaster of Paris; and you will, of course, remember of what chalk is composed in our examination of foraminifera. With these necessary accessories light is chemically analyzed, and it is called "polarized" because it is driven to the poles. Both prism and analyzer owe their properties to thin films in invisible layers, and as the pencils of rays or beams of light pass through them, the compound ray

gets disintegrated, and we behold the three colours, blue, red, and yellow, in all their native glory. This is all I can tell you about polarized light, and it may be that part of this is only conjectural. I do not believe that, notwithstanding this is the age of photography and electricity, we shall ever know the scientific secrets of the composition of a ray of light till we get to know, by personal intimacy, Him who is the Light of the world.



The effect of polarized light upon crystals of salicine, found in the common willow.

Now here are crystals of citric acid, produced by making a solution of that chemical, then allowing the moisture to evaporate, and then, when the solid parts remain, covering them with Canada balsam to preserve them and assist their transparency. What *do* they look like? Flowers, all delicately laid out upon richly coloured glass. Here, too, is chlorate of potash, and I know of no better resemblance which it presents under polarized light than a scientific friend once used when he said it was like "crushed cathedrals!" The glory and beauty of Gothic architecture, in ruins, is here

fairly represented, and a dissolving view may be immediately obtained by revolving the milled head either of the prism or analyzer.

You remember how in our botanical studies we were surprised at the wonders displayed in our skeleton leaves. Without polarized light their perfect beauty would all lie concealed; and as for the *Deutzia* leaf, why, when we get a dark-blue background, and the starry cuticle in bright gold, we have seen that it resembles a glorious patch of the heavens laid down upon the microscope, and we really seem to be surveying that land which is far off. Then, because it is always wise in the study of nature to compare one thing with another, let us take the so-called palate of a limpet. This, we shall examine, measures very nearly two inches in length; it is commonly called the tongue, and consists of a vast number of teeth, which are used for cutting through the shell of an oyster when the limpet goes after its dinner. You have seen good-sized pin-holes, I dare say, on oyster-shells. They have been sawn by such parasites as the limpet, who knows just where to reach that strong but solitary muscle with which the oyster closes the door of its dwelling on the approach of an intruder. Perhaps you may have attempted opening the shell with your fingers, and, if so, you will know what power is in that muscle; but the limpet, with its saw-like tongue, cuts through the shell, and very often the muscle as well, when the poor bivalve is at its mercy.

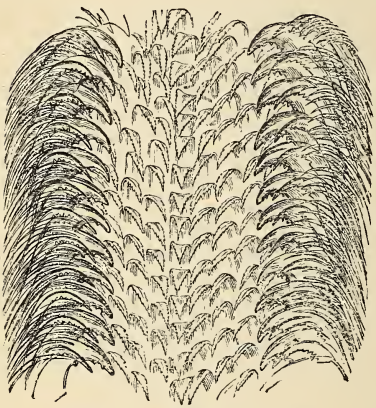
It is strikingly interesting to reflect upon the remarkable age in which we live. In our daily papers, amidst all the strife of politics and the bustle of life, yet what room do some find for contemplating the wonders of nature in little things! While writing upon the palate of the limpet, I observe some very interesting articles in the *Standard* newspaper, from which I learn the true

meaning of a few words I heard with profit many years ago in a Protestant church in the charming Swiss valley of Lucerne. The preacher was enlarging upon the Christian's hold of the Saviour, and he besought his hearers to "cling to Him as the limpet does to the rock." I remember with thankfulness the words, and they were those. The newspaper correspondent tells us how the limpet *does* cling to the rock. He speaks first of its amazing power of doing so. "An ordinary limpet, the common species of our coast, weighs, when deprived of its shell, within a fraction of half an ounce. Yet, when pulled in the line of its plane of adhesion, a force exceeding sixty-two pounds is required to loosen its powerful grip upon the rock, or, in other words, upwards of 1984 times the mollusc's own weight. An ingenious calculation has also been made as to the influence of atmospheric pressure in the operation. Thus, the superficial base of the individual limpet is about 2·4 square inches, which, taking the pressure of the air at 14·7 pounds on the square inch, would only account for something over thirty-five pounds and a quarter—or little more than half the power exercised in the air by the shell-fish. In the water its tenacity is even greater, so that merely meteorological dynamics fail to explain the tenacity of the little beast. Nor will muscular strength account for it. Many molluscs are, as we know, very powerful. Before an oyster can be opened, a force 1319½ times its weight must be exerted. If the limpet be divided vertically from top to bottom as it stands on the rock, and two other deep incisions be made in a horizontal direction, thus destroying all the muscular power of the base, and any possible vacuum between it and the rock, the adhesion, nevertheless, continues as firm as before. Even the death of the animal does not destroy its

adhesiveness. We must therefore seek for some other agent. . . . No feature in its humble economy is thoroughly understood. Physiology, with a view to Darwinism, is now the fashionable pursuit, and will, perhaps, last long enough to allow students to discover that, after all, they are running in the wrong direction." * These interesting words have come to me while you and I have been contemplating what is called this little creature's tongue, but which is really its palate.

What would my friend say to the story of the limpet, who declared he would only believe just what he could understand?

What will my devout brother or sister say to the remark of the eloquent Swiss preacher, who told his hearers to "cleave to Jesus as the limpet cleaves to the rock"? And what a fine saying is that of Dr. George MacDonald's: "Too much light, too many words, too much revelation, blinds or stupefies"! Yes, it is proverbially but strictly true, a man may be blinded by excess of light.

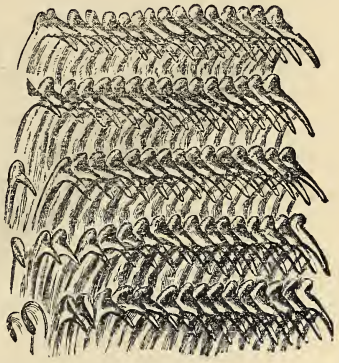


Palate of sea-snail (*Trochus*).

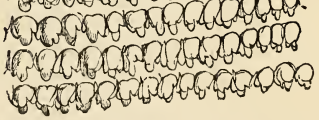
Here is the palate of a winkle, and here a whelk, and here are others of slugs and snails, which very much resemble those of the limpet. Our very best guide to these remarkable "tongues" will be Dr. Carpenter, who tells us that "we should be altogether wrong in conceiving of them as having any

* Extracted from an article in the *Standard*, April 12, 1890.

likeness to that on which our ordinary ideas of such an organ are to be founded. For, instead of being a projecting body, lying in the cavity of the mouth, it is a tube that passes backwards and downwards beneath the mouth, its hinder end being closed, whilst in front it opens obliquely upon the floor of the mouth, being (as it were) slit up and spread out, so as to form a nearly flat surface. . . . The length of the tongue, and the number of rows of teeth, vary greatly in different species. Generally speaking, the tongue of the terrestrial Gasteropods" (that is, such as land-snails) "is short, and is contained within the nearly globular head; but, the rows of teeth being closely set together, they are very numerous, there being frequently more than 100, and in some species as many as 160 or 170, so that the total number of teeth may mount up, as in *Helix pomatia*, one of the garden shell-snails, to 21,000; and in *Limax maximus* (the great spotted slug) to 26,800."



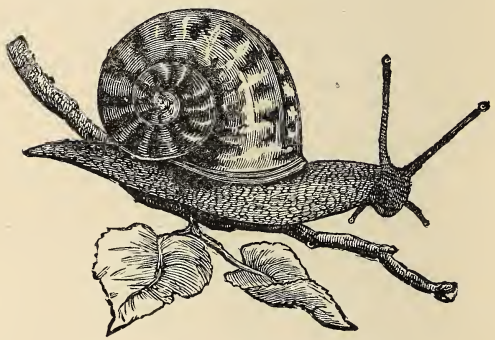
Palate of sea-slug (*Doris tuberculata*).



A portion of greatly magnified teeth of the garden snail, separated to show their form.

You would be wearied with a description of the marvellous beauty of these palates or tongues when nicely seen either by polarized light or the dark-ground illumi-

nation. Some resemble wheat-sheaves bending beneath the grain, each ear representing a row of very sharp and destructive teeth; others resemble a portion of the wall of some armoury, where sword-blades, bayonets, and other instruments of destruction glitter in the light we throw upon them in astonishing brightness; and we leave off with the conviction that the common enemy of our garden plants, the great black slug, or the edible snail, whose eyes are at the tip of its two horns, and who crawls along



Garden Snail.

with its curious house on its back, containing many furnished chambers, is a thing to be wondered at, after all.

Who would think of looking for the beautiful in the structure of the hard horny hoof of an ox? But what tongue can describe the remarkable nature of this very common object for the microscope! It is built up in the most elaborate fashion, and, when seen under polarized light, suggests the most gorgeous patterns for various fine-art objects.

Here again is a transverse section of the horn of a rhinoceros. You will immediately suppose it is an

elaborate pattern for a splendid Turkey carpet. When transverse sections of this object are viewed by polarized light, each particle is seen to be marked with a cross, somewhat resembling starch-grains, and the lights and shadows of this cross are replaced by contrasted colours, when the selenite plate is interposed.

The cross: its lights and shadows! I have already taught you in a former work, "The Starry Cross," that we see the "shadow" repeated in almost every part of natural history; not only is there a "natural law in the spiritual world," but the sign of the cross—which, to the earliest of the human race, and ages before the Prince of life was lifted up upon it, was, it is said, the sign of perfection—is, by a spiritual law, imprinted, as if it were God's sacred mark, in every part of the natural world.

In this transverse section of a remarkable tree as seen under polarized light, not only is the cross visible exactly as represented by the early painters, but it is fixed in a mound of supporting earth; and the medullary rays, starting from the head of the cross, very much resemble the rays of glory, which we have seen in the most costly of pictures, and which gives a new colour to the motto of a very dear friend—

"Christi crux est mea lux."
(Christ's cross is my light.)

This unique specimen is called *Bauhinia Chinensis*, after two botanists, John and Casper Bauhin, who discovered the plant last century. It is a native of Ceylon, and flowers on St. Thomas's Day, and, because its petals are spotted with crimson, it was said by the superstitious to be sprinkled with the blood of the saint, who is said to have suffered martyrdom in India. Could they have known that a transverse section, when seen with the

microscope, exhibited such glory as we see, how would it have added to their enthusiasm! *

And now, before we part company, may I venture upon giving you a little homely advice as to the best course to pursue, supposing you are the fortunate possessor of what the late Dr. Lankester called "the most perfect instrument in the world," a microscope?

People have very often asked me where I have obtained the little knowledge I have; and I have, many and many a time, until I have grown familiar with the words, been complimented upon having so good a memory. Let me tell you, then, how I obtained the first, how I have improved the second, and how *you* may obtain and improve both knowledge and memory.

First, I have made it a point of duty, whenever reading from books, newspapers, or serials, but, above all, when I have enjoyed the conversation of any social or scientific friend, to make a note of thoughts and facts in a commonplace book, from whose notes many of these pages have been compiled. "When found make a note of it,"—that is a well-known saying; and I have filled several volumes with those short notes. By the simple fact of writing such memoranda they became fixed in the memory, and by this practice the memory becomes strengthened; and you will be astonished, also you will astonish others, at the quantity of interesting matter which may be thus crammed into an ordinary-sized brain: and, if you know how to do it (but nobody can say how *that* property is to be obtained), it may be drawn out as it may be required, as wine from a vessel.

Learn, that when your eyes are opened to the simplest laws of nature, you have incurred, in that privilege, a deep responsibility. *Go and teach others.* In the town of

* See a true figure of this specimen on the title-page.

Leeds, some years ago, there was a dog whose leg was run over in the roadway by a cart-wheel. Some good Samaritan picked up the poor brute, and, carrying it to the nearest surgeon's, had the broken limb bandaged, and the dog recovered. The same dog, some time after, was passing along the same road, when he witnessed a brother-dog in the same predicament that he formerly had been in—namely, another wheel had broken *his* leg. What would you have done in a similar case? Just what that dog did. He seized hold of his suffering relative, rushed off to his old friend the surgeon's, and, depositing him on the floor, looked up into the face of his benefactor, as much as to say, "Please do for him what you so kindly and successfully did for me."

Go you and do likewise. You will be surprised at the effect of teaching. If you know but little, go and teach that little, and it will grow with amazing rapidity; for while watering others, you will be abundantly watered yourself.

My first lesson in the microscope was about thirty years ago, and, during those thirty years, after business hours, teaching others has been the grand and gratuitous delight of my life; and, because I have never neglected to associate the great Author of the universe with His works, He has honoured me with very much of success, and many sacred and, I trust, eternal friendships, which have made that long period a pleasant dream.

Never mind what others may say of your associating science with religion: the first is really but the handmaid to the second. And remember, it is written—and I am one of the many witnesses who have found it to be true—"Them that honour Me I will honour, and they that despise Me shall be lightly esteemed."

In your readings and studies follow a good guide, and

never be ashamed, either of your aim to glorify God, or to confess your own ignorance.

An American author, writing of the Dutch entomologist Swammerdam, says, "Those who look into the works of Swammerdam will be abundantly gratified, whether they consider his immense labour and unremitting ardour in these pursuits, or his wonderful devotion and piety. On the one hand his genius urged him to examine the miracles of the great Creator in His natural productions, while on the other the love of that same All-perfect Being, rooted in his mind, struggled hard to persuade him that God alone, and not His creatures, was worthy of his researches, love, and attention."

Here is an extract from one of Swammerdam's prayers: just compare it with the "*ifs*" and "*buts*" and "*uncertainties*" and "*supposes*" and "*doubtfuls*" to be found in the modern "Descent of Man," and then frankly tell me which is the most worthy of your acceptance.

"O God," he exclaimed, "how Thy works infinitely surpass the reach of our feeble understanding: all that we actually know of Thee, or ever can, is but a faint and lifeless shadow of Thy adorable perfections, in contemplation of which the brightest understandings grow bewildered!" Such were the words of that clever old naturalist.

How many arguments for the truth of that divine system of religion revealed to us in the Bible, may be drawn from the testimony of a multitude of characters illustrious in science and literature, the profoundest students either of nature or theology!

"Newton, whose mind burst the fetters fastened by nature upon our finite conceptions; whose science was truth, and the foundation of whose knowledge was philosophy, which, resting upon the basis of mathematics,

cannot lie,—Newton, who carried the line and rule to the uttermost barriers of creation, and explored the principles by which all created matter exists and is held together,—this Newton was a *Christian.* The great Boyle, whose life was devoted to an examination of the organic structure of matter, even to the inanimate substances upon which we tread, and who was therefore peculiarly qualified to 'look through nature up to nature's God,' was the most confirmed and devout believer in all those truths of Christianity, which by some are now held in contempt, as despicable and drivelling superstitions. Locke, whose office was to detect the errors of thinking, by going up to the very fountains of thought, and to direct the devious mind of man to the proper track of reasoning, by showing him its whole process, from the first perceptions of observation to the last conclusions of argument; putting a rein upon false opinion, by practical rules for the conduct of human judgment;—this man also was, to the highest pitch of devotion and adoration, a *Christian.* Should it be said that these men were only close thinkers, and lived in their closets, unaccustomed to the traffic of the world, and to the laws which practically regulate mankind, not so was the never-to-be-forgotten Sir Matthew Hale, whose faith in Christianity was an exalted commentary upon its truth and reason, and whose life was a glorious example of its fruits; whose justice, drawn from the pure fountain of the Christian dispensation, will in all ages be a subject of the highest reverence and admiration. If it be asserted that the Christian fable is merely the tale of an ancient superstition, and may soon be detected by a proper understanding of the mythologies ('beautiful myths') of the heathens, the reply is easy—Did Milton understand those mythologies? Was he versed in the superstitions of the world? They were the subject of

his immortal song, and though shut out from all recurrence to them, he poured them forth from the stores of a memory rich with all that man ever knew, and laid them in their order as the illustration of real and exalted faith, the unquestionable source of that fervid genius which has cast a kind of shade upon all the other works of man.

> 'He passed the bounds of flaming space,
> Whence angels tremble while they gaze;
> He saw—till, blasted with excess of light,
> He closed his eyes in endless night.'

"But it was the light of the *body* only that was extinguished; the *Celestial Light* shone inward, and enabled him to justify the ways of God to man." *

Let me beseech you to "beware lest any man spoil [that is, *rob*] you through philosophy and vain deceit, after the tradition of men, after the rudiments of the world, and not after Christ." † I have sometimes been asked how it is that so many have erred from the faith in the study of what is called "nature," expecting to obtain in the visible world an *explanation* instead of an *illustration* of the written revelation; and I have found, I think, an explanation in the Book which has been the solace, support, and comfort of my whole life,—those words which were once addressed to the mother of the great Jewish lawgiver by the Egyptian princess, "Take this child and nurse it for me," ‡ which may be understood as applying to *any* gift or talent entrusted to our keeping; for it is true that "to *every* man is given according to his several ability" (to use it): § and, verily, I can say, the promise, in my own case, has been richly and literally fulfilled, "*I will give thee thy wages.*"

Learn never to despise the value of little things. There

* Lord Erskine. † Col. ii. 8. ‡ Gen. xi. 7.
§ Matt. xxv. 15.

is a commonplace saying with which all are familiar, "Take care of the pence; the pounds will take care of themselves:" the words apply to many other things than gold and silver. "Little things!" Why, Ehrenberg, to whom I have previously referred you, carried his little microscope, which he tells us he bought in the streets of Berlin for thirty shillings, to all parts of the world, for the purpose of observing the microscopic and invisible beings that inhabited the earth. And what did he discover? Amongst a multitude of other things, that the mountain meal, as it is called, in Norway, contained eighty per cent. of animal matter, consisting of infinitely little organic bodies, being so little, that ten millions of millions of them might be required to fill the space of one cubic inch, and yet in the smallest of those creatures there might have been found several stomachs besides other organs. While, from their little siliceous (flinty) bodies, the solid rocks and big mountains were formed, and out of them, when lime and soda were added, the finest glass was manufactured, from which lenses might be fabricated for the microscope; whilst other purposes, such as the fusing of metals, and the preparation and composition of food in the time of famine, were included in their usefulness.

"To what strange uses" do these invisible animalcules "come at last"! In the earlier part of our story I have told you of what Dr. Dallinger, about two years since, said about the glasses he employs, in these words: "No instrument in the hands of science has touched a higher perfection than the microscope. The last quarter of a century has seen such an advance in optical perfection and mathematical formulæ as the wildest enthusiast never dreamed of, and still immense strides are being made." He had lenses in his possession then, he added, that were made so perfect as to astonish experts, who would, only

three years before, have thought such impossible. "A quarter of a century" ago leads us to the year 1866, and, amongst the many interesting memoranda of my commonplace books, I find the following: "Mr. Powell" (of "Powell and Lealand," one of the best of microscope-makers in the world) "told me, Nov. 5, 1859, while showing me the smallest lens of his one-sixteenth object-glass, which he then charged £16 16*s.* for, that its diameter was only the twenty-fifth part of an inch, and that such a lens could be ground to such a mathematical nicety that it would distinctly present the object to the eye when magnified, with the fifth eye-piece, 4800 diameters—which is, in fact, twenty-three millions and forty thousand times, superficial measurement. The material he used was chiefly foreign glass, very pure, and when brought over, about the size of a cheese-plate, three-quarters of an inch thick, each cake cost £11." Subsequently, the same celebrated makers exhibited what the *Journal of the Microscopical Society* for February, 1864, in a report of the president's address, called "a triumph of artistic skill," in which the one-sixteenth glass of 1859 had grown to a twenty-fifth, the magnifying power greatly exceeding that of their greatest figure of five years previous; and the same authority then said, "We cannot doubt that the wonders of creative beneficence will be developed in proportion to our extended means of investigation, and we can fully testify to having repeatedly seen, under this objective, evidences of structure that are, under ordinary powers, utterly indistinguishable."

These prophetic words were uttered about a quarter of a century ago; since then the one-twenty-fifth has, by the same firm, grown to a one-fiftieth object-glass, and the cost, as compared with that of the previous lens, risen from about

£25 to £80. The reader can more easily imagine what the almost incredible magnifying power of *this* "triumph of artistic skill" will do, than I can either calculate or describe, when the more than "double-million magnifying power" of Charles Dickens is brought into action.

But such a glass as this is never meant for ordinary eyes. Only those of so deep a thinker as I have already mentioned are able to see how to manage such a marvellous piece of what he truly calls "optical perfection."

But the reader will ask, is this perfection to stop here? If ever diamonds, as some fancy, may become sufficiently plentiful to be used as lenses for the microscope, what may *then* be the result of microscopical science!

Can we reflect upon such thoughts as these without being overwhelmed by the glory and beauty of the world we live upon? And is it not a natural step from *that* to the devotional consideration of Him who is its Great Architect?

With such lenses as these "every grain of sand becomes an immensity, every leaf a world, every insect an assemblage of incomprehensible effects in which reflection is lost;" * and we exclaim, with "Zanoni," that not a mote in the sunbeam, not an herb on the mountain, not a pebble on the shore, not a seed far blown into the wilderness, but contributes to the love that seeks in all the true principle of life, the beautiful, the joyous, the immortal. What may we not see with our new eyes!

I have thus opened the door for you to enter which leads to the invisible world, and I have humbly described for your imitation what effect the objects we have seen there has had upon my own mind; and I have warned you what a different effect it has unfortunately had upon the minds and lives of others. If you believe the Bible

* Lavater.

to be the written revelation of God, and the beautiful objects of nature the pictures which illustrate the divine truth it contains, then hold fast "that thou hast, that no man take thy crown." I believe that the great spiritual adversary has many emissaries at work, both in the church and in the world, in different forms and garbs, and that their chief is what is called materialism; that under this name his prime minister busies himself in the church as well as the world, and that many great and noble minds have been blighted by first listening to the voice, which whispered into their ears, as it did to one of old, "Yea, *hath* God said?"

Do you know what "blight" is? "The word is used in common language in an exceedingly loose and undefined way," says the author of the "Micrographic Dictionary." "Blight is, indeed, 'in the air' in many cases, since a frequent source of disease in vegetation is sudden change of temperature, or hygroscopic condition of the atmosphere, deranging the processes of evaporation and respiration in the tender, actively developing portions of the foliage or inflorescence of plants." It is also often "in the air" in another and still higher sense, and we see the pernicious effects of "blight" just as much in mind as we do in matter; and this is why I close our little evening studies with the microscope with a warning as to the seductive spores which belong to the invisible world of doubt, but which lie thickly scattered in the words of many authors and teachers who have been beguiled, as I believe, by the insinuations of the spiritual adversary.

"Blight in the air!" There are blighted minds—I know, alas! of several; and it is because I know, that I warn you in your microscopical studies, which are the best antidotes to materialism when rightly seen and used;

but, like all other blessings, liable, if abused, to lead to mental and spiritual ruin.

"Many mighty men are lost;
Daring not to stand,
Who for God had been a host,
By joining Daniel's band!
Dare to be a Daniel! *dare to stand alone.*
Dare to have a purpose firm! *dare to make it known!*"

With the aid of the microscope we have been told that, during moist and unpleasant weather, the spores of various fungi commonly called "blight," can be discovered in the atmosphere merely by exposing a slip of glass in a current of air. These supposed spores were very prevalent and very distinctly visible to the microscopist during the prevalence of cholera. I once astonished a farmer by telling him that what he called "smut" in wheat was as true a vegetable as a cabbage. "Examined under the microscope, each grain is found to be converted into a vast number of minute round balls or sporules of a deep brownish-black colour. Bauer says that in the 16,000th part of a square inch he counted forty-nine of those sporules, so that four millions of them may exist in a single *grain* of corn." *

I shall never forget the amazement of an Irish friend to whom I showed the growth of the potato disease; when he saw what to the eye only appeared a brown mass of decomposition to be a mass of rapidly growing plants, he knew of no words to express his astonishment. You will not forget a former description of our vegetable caterpillar, nor, I hope, the lesson we may learn from each of these inhabitants of the invisible world—the danger of receiving the first seed of evil.

There is another vegetable parasite, too well known to the farmer, called "dodder," which means a *ravelled*

* Macmillan, in "Footprints of the Creator."

thread; it is sometimes called "*Hell-weed;*" it grows almost destitute of leaves, and bears usually a small yellow flower. It creeps along the ground in a most insinuating and stealthy manner, and casts about, with its long twine-like arms, for something to lay hold of and cling to. As soon as it comes in contact with the living stem of some other plant, it throws out a sucker, by which it attaches itself, and commences to absorb the sap of its foster-parent; it then ceases to have any connection with the ground, it dies at its own roots, and it lives upon and at the expense of the plant about which it has encircled itself. As it grows it throws out fresh suckers, establishing itself firmly on its victim. After making a few turns round one stem, the dodder finds its way to another, and thus it continues turning and branching till it resembles "fine, closely tangled, wet catgut," and even then, as though not satisfied with this pitiable exhibition of meanness, it eventually chokes, strangles, and kills the plant upon which it has lived.

Why have I told you this story, which a worthy minister * sent me while writing these pages? It is to show you, by an illustration, how the reception of doubt, when it is entertained in the mind and not rejected, leads too often to the ruin of the soul. This story was written for and spoken to children at a May morning flower service. May I tell you another, the combination of the two exactly conveying the lessons which I have considered it a duty to convey while looking into the wonders of the beautiful world on which we live?

Some years ago there was a German prince who lived in an old castle on the banks of the Rhine; he was a good Christian man, and had an only son, who was a very good young man, and not only a comfort to his father,

* Rev. Morley Wright.

but a blessing to all the people who lived on his father's land.

It happened once, while this young man was away from home, that a French gentleman came to the castle on a visit to the father. This visitor was an atheist; he did not believe in God, and never thought of trusting Him for anything.

One day, when they were talking together, he said something about God which grieved his friend's heart very much, and he could not help saying to him, "My friend, are you not afraid of offending God, who reigns above, by speaking of Him in this way?"

"No," said the gentleman. "I have never seen God. I know nothing of Him, and care nothing about Him."

His friend said nothing more to him at that time, but resolved to try and show him how wrong he was. So, the next morning, he took him about the castle grounds to show him different things. In the first place he called his attention to a beautiful picture that hung on the wall. The gentleman admired the picture very much, and said, "Whoever drew this picture must be a very good painter."

"My son drew that picture," said his friend.

"Then your son is a very clever man," replied the Frenchman.

Then the two went into the garden, which was beautifully laid out, with a great variety of beautiful flowers and trees.

"What a beautiful garden!" said the gentleman. "Do tell me who planned and arranged it?"

"It is my son's work," was the answer.

"Indeed!" said the other. "I am beginning to think very highly of him."

Then the gentleman took him into the village and

showed a nice cottage which his son had built, at his own expense, as a home and school for all the young children in the village who had lost their parents, where they could be taken care of and educated. The little children in the home seemed so clean and happy that the Frenchman was quite delighted with the sight of them, and when he returned to the castle he said to his friend—

"What a happy man you must be to have so good a son!"

"How do you know that I have so good a son?" he asked.

"Because I have seen his works, and I know that he must be good and clever if he has done all that you have shown me."

"But you have not seen him!"

"No; but I know him very well, because I judge of him by his works."

"Very true," replied his friend; "and it is just in this way that I judge of the character of our Heavenly Father. I know by His works that He is a God of infinite wisdom and power and goodness, and every star that twinkles in the sky, and every tree that grows in the field, and every flower that blooms in the garden by day, seems to tell me that I ought to love Him and trust Him."

My story is ended. I could have wished to have lengthened it by more advice to you in respect of the instrument. Should you be encouraged by it to purchase a microscope for yourself, I should not leave unsaid a word or two about object-glasses. Don't think that *the* thing to do is to make a flea as big as an elephant. I have learned to educate my eye by using the lowest powers, which, with the help of an extra eye-piece or two, and an extension of the draw-tube, will do all you want, to

commence upon. A three-inch glass will be most useful; even a four-inch is most valuable in the examination of living flowers. Beyond a half-inch glass magnifying one hundred diameters, that is, ten thousand times, to begin with, it is unnecessary to go; when you have made steady progress then you may venture upon higher magnifying powers.

Never forget that in the study of the works of God, if you would grow in knowledge, the same secret has to be discovered as in the study of His Word—*illumination*. I have known those who possessed excellent microscopes, but who failed in the management of light. I have reminded you of the good motto for every good thing in every good mind, "Incessant pains the end obtains." Preliminary failure is frequently necessary to ultimate success. I found this saying true in my first lessons in self-culture; so may you. I remember once cutting out the eyes of a house-fly and mounting them *dry* in a deep cell. Imagine my surprise soon after, on examining my object, finding that, lodged in those thousands of eyes, had been the invisible spores of a fungoid plant, which began to grow directly I mounted it, and, like an ivy creeping into the church window, was filling up the facets of my interesting object: *that* drew my special attention to insects' eyes and parasitical growth, the study of which has occupied me from that time to this hour.

And now "cometh the end," and I must reluctantly bid farewell to this tenth volume, which henceforth shall be an adopted child of that happy family, the Sunday School Union. I can scarcely hope that it will be to the reader what it has been to me, because in my own mind it has been a recalling of past memories, the culling of old thoughts, in which so much of true and lasting pleasure has

been happily associated in microscopic research, associated with the dear ones whom I have "loved and lost awhile."

In this book, the child of my old age, I have only been able to mention a few illustrations of the wonderful works of God, endeavouring to keep *Him* steadily in view, never forgetting the pretty story told us of the late Emperor Frederick, of Germany, who, while attending the examination of some school-children, took a coin from his pocket, and asked to what part of the natural kingdom it belonged, —when he received the ready answer, "The *mineral* kingdom;" then, taking a flower from his button-hole, he repeated the question, and "*Vegetable* kingdom" was the reply; and then he asked, "And to what part of the kingdom do I belong?" Then there was a long pause, for how *could* those juvenile subjects of an emperor describe *him* as an "*animal*"? At length some nervous youngster said, "The *kingdom of God*." And the monarch is said to have added, with a tear in his eye, "God grant I may indeed belong to His Kingdom."

This threefold cord, I have ventured to use in the preceding pages, in the fond hope that, while advocating the possession of a microscope which will assuredly be found to be one of the readiest, most effectual, economical, and useful teachers in the world, will, when rightly applied, not only prove to be a new sense to the mind, but a great "aid," if there be such a thing, to faith. And my earnest wish and loving prayer for any who may devote a few hours to the contemplation of the truths I have imperfectly taught is, that, rightly, reasonably, and scripturally, taking the revelations of the microscope as so many illustrations of the written revelation in the Bible, they may fully and heartily and savingly accept the one while they are privileged to behold the other; and then, with me, when they come to the last chapter in

the story of life, and have to say, "*It is finished,*" they will be as fully assured as I am of the truth of some comforting words spoken to me, many years ago, in the following verses:—

"There is a safe and secret place
Beneath the wings divine,
Reserved for all the heirs of grace:
Oh, be that refuge mine!

"The weakest saint may there abide,
Uninjured and unawed:
While thousands fall on every side,
He rests secure in God.

"The angels watch him on his way,
And aid with friendly arm;
And Satan, watching for his prey,
May hate but cannot harm.

"He feeds in pastures large and fair
Of 'WORKS' and 'WORDS' divine!
O child of God, O glory's heir
How rich a lot is thine!

"A Hand almighty to defend,
An ear for every call,
An honoured life, a peaceful end,
And heaven to crown it all!'

APPENDIX

THE NATURAL HISTORY OF A CORAL REEF.

(*See* page 240.)

I HAD just finished correcting the proof of the preceding pages when my attention was directed to the geological formation of the peninsula of Florida, in the United States. My friend, C. C. Hoyer Miller, Esq.—having just returned from a survey of the vast beds of phosphate for which that place is so famous—informs me that in one county alone, consisting of between 5000 and 6000 acres, he thoroughly tested one tract of 600 acres, and the result showed upon the analyses, from 66 to 70 per cent. of phosphate of lime, and that the probable estimate of the entire bed of 600 acres would yield a total quantity of 1,800,000 tons.

What is phosphate of lime? and what is its use? and how came this vast deposit to be where it is now discovered?

It was absorbed into the system, and utilised into the structure of multitudinous polyps in the erection of their dwellings, just as an oyster employs the material in the structure of its shell, and it is the very ingredient necessary in the fertilization of plants, and is converted by the chemist into manure for the food of the necessaries of life, and is a lively illustration of the words which St. James uses when he speaks of "the course (R. T. the *wheel*) of nature"—a reference, I believe, to the acknowledged fact

that every bit of dust has been alive, the earth and all its contents being used over and over again, as a wheel in action is turning continually round.

Professor Agassiz says that the southern half of the peninsula of Florida, which is built up of coral reefs, took 135,000 years to form, and my friend has very kindly authorized my using the information he received from Dr. J. Schrader illustrating the process of formation, which will exactly answer the question, How did these vast beds of phosphate of lime come to be in the position where he saw them?

"Far back in the misty ages of the dead past," he says, "countless centuries before Troy or Athens had a being, before Nineveh was destroyed, or the Pyramids were built,—hundreds of generations before the Tower of Babel rose, or the hail of fire swept Sodom and Gomorrah,—innumerable ages before the embattled walls and turrets of ancient Babylon rose above the Chaldean plains; farther, still farther back,—thousands of years before the first rose blossomed in the Garden of Eden, a little animal, one of the lowest orders of animal beings, lived and toiled beneath the ocean's tide. That animal—scarcely more animal than vegetable—was the polyp, the coral animal, or, as it is sometimes called, the coral insect. He must have led a monotonous life, subsisting on limestone, and making coral day after day and year after year, with never a change of diet or occupation, with no neighbours of a higher order than himself, for there were few forms of animal life in the ocean then, and none on the land. But he was not ambitious; and, having plenty of 'sea room,' he applied himself diligently to his life-work, forming coral, raising the ocean bed, and laying the foundation for future islands and expanding continents.

"There were great swelling tides in those days; tides which swept with impetuous fury, far inland; lashing the feet of the mountains; and in their retreat, carrying back the disintegrated rock and other calcareous matter, as fresh material for the toiling polyps.

"In the remote Silurian age, at the very dawn of palæozoic time, the little polyps began their appointed work. Centuries, epochs, ages pass; and still the little animals toil on. The Carboniferous age is ushered in, when, as we are told, 'the waters teemed with fishes of great size and strange forms, and the dry land was covered with a rank and luxuriant vegetation, of ferns and coniferous trees, and strange forms, like gigantic reeds and club-mosses.'

"Still the 'whirligig of time' revolves. The Reptilian age—when the Ichthyosaurus, the gigantic lizard, basked in the sunshine—comes and goes. The Eocene, Miocene, and Pliocene Epochs pass in review; and still the industrious little polyps never 'strike,' nor ask for 'their time,' nor demand an 'eight-hour day'; but, content with their hard fare, they go right on, rearing beautiful submarine structures in accordance with the original plans of the Great Architect.

"Now, as the result of numberless ages of incessant labour, coral reefs appear, over which the great river of the ocean, the Gulf Stream, swirls, frets and breaks, depositing the sediment brought from distant climes. The polyps retire (to take another contract farther out in the deep) and other forces of nature continues the work. In time, the coral reefs become a cluster of little islands. Meanwhile, change succeeds change on the broad face of the globe. Innumerable fishes fill the seas; and on land, the mastodon, the glyptodon, the dinotherium, and the prehistoric elephant live their appointed time, and become extinct, to give place to other forms of animal life. The calm waters of the bays, inlets and estuaries among the islands are well suited to the habits of molluscs, crustaceans, radiates, and cephalopods; and here, oysters, clams, lobsters, sea urchins, cuttlefish, octopods, the nautilus, and many other naughty things, find an abode. Generation after generation, century after century, living, dying and casting their untenanted shells upon the substratum of coral, they are unconsciously forming a bed of marl.

"These quiet retreats also attract the monsters of the great deep, and here the porpoise and the dolphins play; and the plesiosaurus and the great shark engage in deadly conflict, crimsoning the limpid waters with their life blood, while pelicans, cormorants, and other fish-eating birds watch the combat with selfish glee. Layer upon layer of the bones of fishes and marine animals are strewn on the bed of marl; the sea-birds contribute their share to the up-building, and still the work goes on. From the accumulation of animal matter, ocean drifts and sediment from the Gulf Stream, the sea-bed continues to rise. The cluster of islands becomes an everglade, with here and there a tufted elevation; while upon the shores the ocean surf casts the seeds and roots of trees and plants, contributions from every land to the rising savanna. A little later, many elevated spots or islands are merged into one; others are connected by narrow strips of land; the deeper bays have become lakes, and the estuaries have become rivers. And now the incipient peninsula is the favourite haunt of the manatee, the alligator and countless millions of animals and birds. A few thousand more years elapse; and an adventurous navigator discovers the finished work, which the humble polyps began. The coral reef, the cluster of islands, the everglade, the savanna has now become a bold peninsula, traversed by rivers, dotted with sparkling lakes and clothed in tropical vendure.

"It was Palm Sunday (Pascua Floridæ), when Ponce De Leon stepped upon the shore; and, as if to commemorate the day, the oaks were festooned with mosses; rich ferns and grasses lined the beach; bright flowers were flashing in the sunlight; and high above them, the graceful fronds of stately palms were swaying in the breeze. Thus, in honour of the day, and as an expression of admiration, he called this land of beauty—Florida.

"Three hundred and seventy-two more years had passed, when a son of Adam, in the pursuit of applied science, blazing the way for the extension of a great nation's com-

merce, discovered in this lovely peninsula with its forests of orange groves, the vast sepulchre of millions of creatures which died only to live again in vegetation, and to contribute to the comfort and happiness of man. This antediluvian sepulchre is the phosphate field of the two counties."

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